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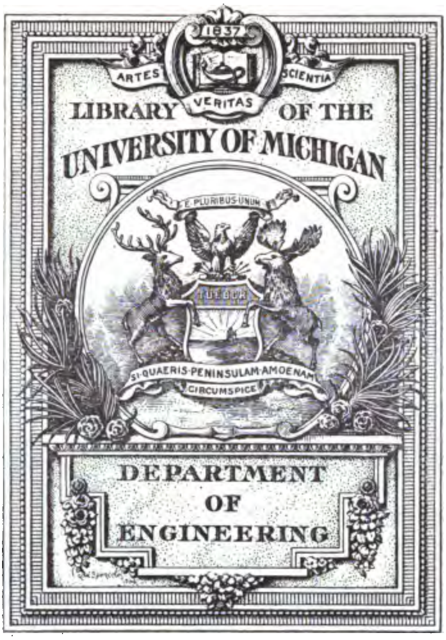

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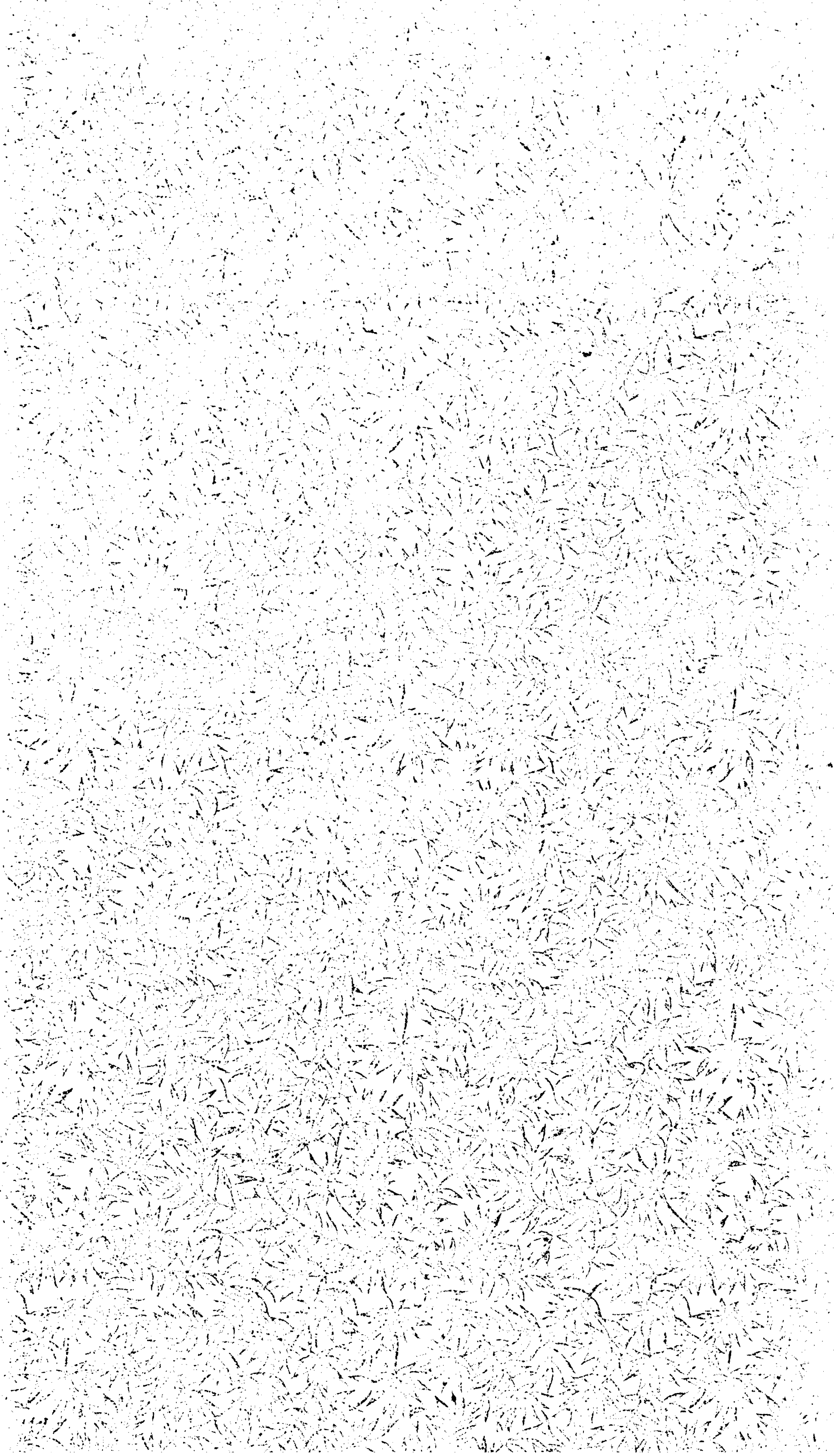

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A TREATISE

ON

STEAM BOILER INCRUSTATION

AND

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METHODS FOR PREVENTING CORROSION

AND THE

FORMATION OF SCALE,

Including Methods for Determining the Constituents and a Description of Dr. Clark's Soap Test for Determining the Degree of Hardness of Water; the Effects of Rain, River, Well and Sea Waters on Steam Boilers; Compounds and Apparatus for Purifying, Softening, Heating, Filtering, Spraying and Separating Foreign Matter from Mine, River, Well and other Waters; Apparatus for Feeding Chemicals with the Water to Steam Boilers, and for Economizing in the Quantity of Water Consumed for Generating Steam in Places Where the Supply of Water is Limited; Devices for Removing the Mud and Sediment and for Blowing off the Less Crystalline Substances and Salt from Steam Boilers; Including also a Description of Compounds for Softening Incrustations and Methods Claimed as Preventives to the Incrustation and Corrosion of Land and Marine Steam Boilers; also a Complete List of all American Patents Issued by the Government of the United States from 1790 to July 1, 1884, for Compounds and Mechanical Devices for Purifying Water and for Preventing the Incrustation of Steam Boilers.

By CHARLES THOMAS DAVIS,

Author of "A Practical Treatise on the Manufacture of Bricks, Tiles, Terra-Cotta," etc.

ILLUSTRATED BY SIXTY-FIVE ENGRAVINGS.

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AS A TESTIMONIAL OF MY PERSONAL ESTEEM AND APPRECIATION OF THE ASSISTANCE

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CHARLES THOMAS DAVIS.

PREFACE.

The incrustation of steam boilers is a subject that has received but little attention compared with its importance.

In this age of progress there is unfortunately too much tendency to neglect those minor details of management which form the foundation of safety in all employments and enterprises.

In no case is this probably so true as in the management of steam generators.

Men who have not had the proper technical training for such trusts are often placed in full control, with *carte blanche* to do as they please with the boilers, provided the necessary steam to drive the engine is promptly furnished. Consequently all kinds of materials designed to prevent or loosen incrustations find their way into the interior of boilers.

Expensive compounds are often purchased and recklessly employed, which, as might be expected, yield only unsatisfactory results.

It was with a view to furnishing reliable information as to the various compounds and mechanical apparatus employed for the prevention of boiler incrustation that the present volume was compiled.

In doing this it was of course impossible for the author to accomplish more than to show the state of the art at the present time.

The tendency of practical inventors for some years past has been to discard chemical compounds and to employ mechanical devices for preventing incrustation.

The author could have greatly increased the size of the present volume by giving a description of all the different mechanical water purifiers and boiler cleaners which have been invented; but as a large number of such inventions possess no substantial claims for recognition, he deemed it best to select only those which have been found satisfactory in practice or which possess novel features.

The matter in Chapter II was compiled from the best German authorities and from Wanklyn's and Frankland's treatises on Water Analysis.

CHARLES THOMAS DAVIS.

WASHINGTON, D. C.,
1114 Pennsylvania ave.,
Sept. 24, 1884.

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STEAM BOILER INCRUSTATION

AND

METHODS FOR PREVENTING CORROSION AND FORMATION OF SCALE.

CHAPTER I.

General Remarks Concerning the Incrustation and Corrosion of Steam Boilers; Composition and Properties of Water; Sources of Water; The Effects of Water on Steam Boilers; Preventions to Corrosion of Marine Boilers.

General Remarks Concerning the Incrustation and Corrosion of Steam Boilers.

Builders of steam generators in our days are commonly awarded the reputation of possessing greater experience than their predecessors. Indeed, so numerous and valuable are the improvements which have been perfected in this class of apparatus during the past two-thirds of a century, that upon a cursory view it might appear that there really remains nothing further to be accomplished in the way of improvement in the construction or care of steam boilers.

But the opposite is really the fact, and the repeated observations of each day clearly demonstrate that we fall far short of having attained a finality in devising and managing steam-making apparatus.

It is true that during the past twenty years there has been made a remarkable advance in the economy of fuel used in steam engines. The general employment of compound cylinders and surface condensers in marine engines has been productive of highly satisfactory results, for instead of being, as at present, only about 2 lbs. per one horse-power per hour, it was formerly 3½ to 4½ lbs., and with Corliss engines equally favorable results have been obtained. It is true that this has been accomplished by perceptibly diminishing the endurance of marine boilers since the introduction of surface-condensers and high-steam pressure. Recent experiments made by M. Georges Marié, engineer of the Paris and Lyon Railway, also clearly demonstrate that the consumption of fuel in good locomotives is only about 3.35 lbs., when the horse-power is measured by the work done at the circumference of the driving-wheels, and 2.91 lbs. when it is measured by the indicator diagrams, the fuel being of good quality and the firing done with care. Considering that locomotives work non-condensing, while marine engines enjoy the great advantage of condensation, it will be seen that even locomotives are much more economical than is usually supposed, the general impression being that locomotives consume as much as from 4½ to 5½ lbs. of fuel per horse-power per hour.[1]

But even with this favorable showing of the best modern practice, if we carefully examine the systems commonly employed for generating steam in our steamships, our manufactories, and on our railways, and compare the results obtained under ordinary circumstances with those emanatory from carefully-conducted scientific experiments, we quickly realize that there yet remains vast room for improvement in the construction and care of steam boilers regarding the power of obtaining highly economical results from the combustion of fuel.

The appalling frequency with which boilers give way without the slightest warning, and prove more or less destructive to life, limb and property, testifies powerfully in corroboration of the truth of the statement that such disastrous results can emanate only from imperfections or mismanagement, and that all the received forms of boilers and methods of construction are unsafe—even the most superior workmanship and material failing to insure perfect security.

It, therefore, devolves upon those having the responsibility of the management of steam generators to exercise strict precaution and take advantage of every aid that will lessen the liability of such accidents, and at the same time extend the period of use of steam boilers, and economize in the consumption of fuel.

The majority of suppositions commonly advanced to account for the ever-occurring boiler explosions and accidents are simply based on purely hypothetical reasons, and are necessarily nonsensical.

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[1] Proceedings of Institution of Mechanical Engineers, May, 1884, p. 82.

Even when vigilant precautions are observed, from the moment a steam boiler is constructed until it is finally destroyed there are numerous insidious agents perpetually at work which tend to weaken it. There is nothing from which the iron can draw sustenance, for the atmosphere without and the air within the boiler, the water as it enters through the feed-pipe and containing mineral and organic substances, the aëriform fluid into which the water is converted, the sediment which is precipitated by boiling the water, the fire and the sulphurous and pyroligneous acids of the fuel, are all natural enemies of the iron, and they sap its strength not only while the boiler is at work and undergoing constant strain, but in the morning before fire is started, and at noon, night, Sundays, and other holidays it is preyed upon by these and other eroding agents. Add to these destroying agents an occasional ignorant, careless or over-confident fireman or engineer, and boiler accidents instead of being described in the newspapers as "mysterious," could often be fully explained in the two words—"natural results."

Deterioration, of course, depends greatly upon the quality of the material employed, the design, and the intelligent care exercised in the use of boilers, consequently it is not possible to accurately estimate the progress of degeneration at first sight.

Experience has clearly demonstrated that the most common agent in promoting boiler explosions is corrosion, which constantly feeds upon both the exterior and the interior of a boiler.

External corrosion is frequently hastened by culpable negligence or ignorance, this being the case when the boiler plate is exposed to the corroding influence of the atmosphere, or to drippings of water from defective roofs, cocks and packings, or from other preventable causes, which, while sometimes slow, are nevertheless certain to cause the wasting away of the iron; or through the stupidity of those who set the boiler on the brick work it may be placed in such a manner that the moisture arising from the ground and the drippings of water from the mountings above can find a lodgment in it, where, concealed and neglected, it steadily feeds upon the plates and eats them away.

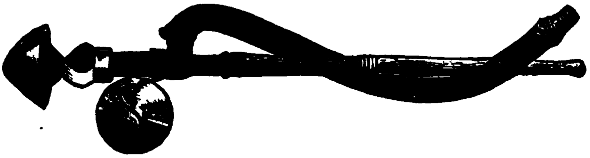
This kind of corrosion is commonly charged to the wear and tear of the boiler; it has nothing to do with wear and tear, but is external corrosion pure and simple, and as such is directly chargeable to carelessness.

Boilers have often been seriously corroded by ashes which have been thoughtlessly allowed to remain in contact with the iron, the alkaline salts which they contain attacking the plates vigorously as soon as the ashes become dampened, which they readily do by drawing from bilge-water in vessels or from the ground ashore by leaky cocks, or by deliquescence from the atmosphere. When wood has been freely used in lighting fires, or large quantities of coal have been fired at one time, it has been found that the soot in tubes and flues has become charged with pyroligneous acid, and that this combination has caused corrosion.[1] A similar result has also been produced from the use of coal by the soot retaining fine dust of ashes, and, consequently, also sulphur acids derived from pyrites in the coal.[2]

Proper care in cleaning flues or tubes and ash pits, and discretion in firing will of course obviate corrosion from the latter two causes.

Flues or tubes should often be swept, as soot, in addition to its liability to becoming charged with pyroligneous acid, as above noted, is a non-conductor of heat, and the short time spent in cleaning them will repay the engineer by the saving of labor in keeping up steam. In an establishment where they used but half a ton of bituminous coal per day, the time of raising steam in the morning was fifty per cent. longer when the tubes were unswept for one week than when they were swept three times a week.

Fig. 1.



The subject of flue cleaning is one of great importance to both engineer and proprietor. With poor tools the work is the most tedious and unsatisfactory of the attendant's duties. Not infrequently boilers are condemned as being too small, when, if properly cleaned, they often would meet every demand. The Cyclone flue cleaner, illustrated in Fig. 1, having a conical shaped head, adjusts itself to the end of the tubes and excludes the air, thereby preventing condensation and insuring a dry current of steam. The auger-shaped steam passage is without obstruction or division from the induction end to the outlet of the passage. A current of dry steam is delivered directly against the face of tubes in an unbroken sheet, continuing through their entire length in a whirling motion, with a sweeping force, thoroughly removing all ashes and other foreign substances, and when daily used greatly improves the draft. The head is cast in one piece, and attachments, consisting of T coupling and hose

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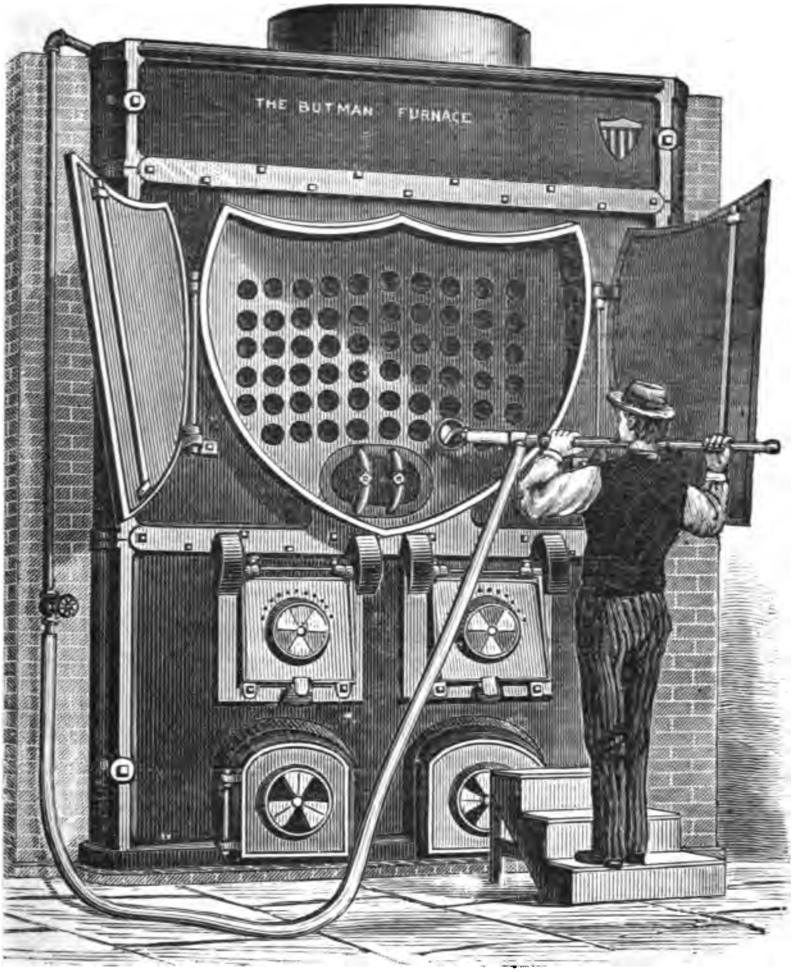
[1] Chem. News, vol. XXX, p. 153. Jour. Chem. Soc., vol. XIII, p. 294.

[2] Chem. News, XXXII, p. 252. Jour. Chem. Soc., No. CLXI, p 796.

Fig. 2.



clamps, are malleable iron. The handle is of hard wood. There are no screws or loose parts to become lost or out of repair. The cleaner requires no oiling or adjusting, and is ready for use at all times by attaching rubber hose to steam pipe, as shown in Fig. 2. The entire operation of cleaning a boiler requires but a short time, and this flue cleaner is adapted to marine, stationery, portable, upright, and locomotive boilers.

This cleaner is made by the Crescent Manufacturing Company, Cleveland, Ohio, in sizes ranging from ¾ inch to 16 inches.

It is not infrequently the case that corrosion results from galvanic action, which is plainly manifest when brass cocks are attached directly to the boiler shell, and the corrosive action is greatly facilitated by the leakage of water, especially salt water, at the joint or connection.

The province of the present volume is not, however, to discuss the construction and external corrosion, but rather to deal with the incrustation and internal corrosion of steam generators, and to describe some of the apparatus, methods, and compounds which have been proposed as remedies.

Corrosion of the shells, tubes, flues, and braces of steam generators is usually caused by the action of saline or acid substances, by oxidation, and by mechanical and galvanic action. Incrustation is the deposit from the water, which adheres to the inside of the shell and surrounds the tubes, flues, and braces of boilers.

Water on becoming steam is separated from the impurities which it may have contained, and, as the impurities of waters commonly employed for steam generators cause damage and promote explosions by forming sediment and incrustation, and, in addition, increases the cost of repairs, it has, therefore, long been a problem in steam engineering to get rid of feculent matter in water which it is found necessary to use in steam boilers.

Nearly all natural water contains more or less mineral matter in solution, as well as organic and mineral matter held in suspension; the latter may be removed by filtration or settling, but matter held in solution can only be removed from water by the agency of heat.

The amount of mineral matter held in solution by ordinary water, as generally supplied to cities, and found in rivers, streams, canals, and fresh-water lakes, varies from 10 to 40 grains per gallon of 231 cubic inches. Well and mine waters contain more, while in some instances water is used for steam boilers containing as much as 250 grains per gallon. But a much less quantity than the latter is sufficient to cause serious inconvenience. This is easily shown. For instance, Prof. Chandler, of Columbia College, New York, in his report to the President and Directors of the New York Central Railroad on water for locomotives and boiler incrustations, says: "It has been stated (page 3) that as much as 1300 pounds of incrustation have been taken from a single boiler at one time. It may seem impossible for so large a quantity of earthy matter to be deposited from waters which average only 17 grains of incrusting constituents per gallon. When it is recollected, however, what vast quantities of water pass into a locomotive boiler, the possibility will be fully conceded. It was stated by a master mechanic on the road that a locomotive in running 40 miles will take in 1800 gallons of water, equivalent to 45 gallons per mile, a quantity which seems incredible. Accepting this statement as a basis for calculation, we have 765 grains, or more than an ounce and a half of earthy matter as a possible average of the quantity which enters the boiler per mile. Multiplying this by 1988, the average number of miles run on this section of the road by each of the 56 locomotives, in one month (Dec., 1865) we have 217 pounds of incrusting matter entering a boiler per month, or 2004 pounds per year. Nor is this necessarily a maximum, as some boilers receive the larger part of their water from stations furnishing water much below the average in purity."

As water is the medium through which most corrosive and all the incrustating ingredients are conveyed to the interior of steam generators, we shall first describe the

Composition and Properties of Water.

Water is composed of the two gases, oxygen and hydrogen, in the proportion by weight of 88.9 parts of the former and 11.1 part of the latter, or 1 volume of oxygen to 2 volumes of hydrogen in chemical combination.

The composition of water can be proved analytically as well as synthetically, a current of electricity decomposing it into its constituent gases, twice as much hydrogen as oxygen, by volume, being produced.

Water, when pure, is colorless (in small quantities) and transparent, without taste or odor, and a bad conductor of heat and electricity. It is slightly elastic; under a pressure of 30,000 lbs. to the square inch 14 volumes may be condensed into 13 volumes. It is 815 times heavier than atmospheric air, an imperial gallon weighing (at 62° F. and barometric pressure at 29.92 in) 70,000 grains, or 10 lbs. avoirdupois; but being the standard to which the gravities of solids and liquids are referred, its specific weight is usually said to be 1.0.

Water contracts and becomes denser in cooling, until it reaches 39°.2 F., when it has reached its greatest density.

On becoming still colder, it begins again to expand, and becomes consequently lighter. Above this temperature the surface of the water—which in large masses is the first to cool—becomes heavier than that beneath it, and falls to the bottom, this process going on until the temperature has descended to about 40° F., when the water on the surface on becoming colder expands, and thus remains on the surface; after this the water under can only become colder by conduction of heat, and as water is a bad conductor of heat, this takes place but slowly.

This peculiar property of water is a most wise provision, for it prevents the possibility of a mass of water of any depth becoming completely frozen, and the lower portions being the warmest, fish life is preserved.

Water freezes or becomes solid at 32° F., and in the act of freezing expands considerably and gives out a large quantity of heat, which before was latent or imperceptible to the thermometer. The force exerted by this expansion is very great, and it is the expansion of water in becoming ice which bursts water-pipes; but until it again melts it cannot, of course, pass through the cracks and tell the tale. Owing to the expansion in the act of freezing ice is lighter than water, its specific gravity being 0.916.

Although water freezes at 32° F., it may, if kept perfectly still, be cooled much below this temperature, but when so cooled, if slightly agitated, as by dropping a grain of sand into it, or walking heavily across the room, it instantly becomes solid and gives out the heat previously latent, rising at once to the temperature of 32° F.

If ice be melted in any vessel by the application of heat, it is found that the portions first melted remain at 32° until the last of the ice disappears, all the heat applied up to this point having become latent, supplying only the place of that given out in the act of freezing. The latent heat of water is 176° to 176°.6 F.

The refractive power of water, or its index of refraction of light, is 133°.6. The refraction increases below 39°.2 F., although density diminishes. It is this refractive power that causes a stick which is partially plunged into water to appear bent.

Water expands by the application of heat between 40° F. and 212° F., at which latter temperature it boils in metallic vessels when the barometric pressure is 29.92 inches. Under pressure it may be heated much above this point without entering into ebullition, and even in open glass vessels it does not boil until it reaches one or two degrees above this. On the first application of heat to water small bubbles soon begin to form and rise to the surface; these consist of air, which all water contains dissolved in it. When it reaches the boiling point the bubbles that rise in it are principally steam. In boiling water in glass vessels, after some time, when all the air has been expelled, the water does not boil steadily, but, owing to the force of attraction acting between the water and the glass, it will remain often still for a moment until the elasticity of the steam bubbles is sufficient to overcome this attraction, when it suddenly boils up violently and expels some of the water from the vessel.

When water is poured on red hot surfaces it does not touch the surface, but remains in the spheroidal state at a little distance from it, being apparently surrounded by an atmosphere of steam. It assumes this state above 340°; when the temperature falls to about 288° it touches the surface and commences boiling.

The boiling point of water varies according to the pressure. As before mentioned, with a pressure of 29.92 inches, it boils at 212°; with a pressure of 27.74 inches it boils at 208° F. This change of boiling point may be used to ascertain the height of mountains—550 feet making a difference of 1°. In a vacuum water will boil at 67° F. Advantage is taken of this in the concentration of the sugar-cane juices and the extraction of the sugar. The application of heat in the ordinary way converts a large quantity of crystallizable sugar into an uncrystallizable state, thus causing a serious loss. By effecting the concentration in a vacuum it takes place in a much lower temperature and prevents this source of loss.

It is to be observed that water evaporates at all temperatures, and its solvent properties far exceed those of any other known liquid.

A very large proportion of all the different salts are more or less soluble in it, the solubility increasing generally as the temperature rises, so that a hot, saturated solution deposits crystals on cooling. There are a few exceptions to this rule, one of the most remarkable of which is common salt, the solubility of which is nearly the same at all temperatures, the hydrate of lime (slaked lime) being more soluble in cold than in hot water, sulphate of lime being also less soluble in hot than in cold water, and insoluble at 302° F., or between 284° and 302° F. It also dissolves gases, but not in equal quantities; for instance, hydrogen, oxygen, and atmospheric air are only soluble in comparatively small quantities, whereas ammonia and hydrochloric acid gases are absorbed to an enormous extent. It dissolves 670 times its volume of ammonia gas at 50° F. and 29.82 inches pressure, and 480 times its volume of hydrochloric acid gas at 40°. Between these two extremes there are, of course, other gases which dissolve it in intermediate degrees. Generally the colder the water the more gas it dissolves. A boiling temperature expels all the gas if it be not very soluble. The solvent properties of water are still further increased when heated in a strong vessel under pressure.

The liquefaction of solid bodies by solution in water obeys the same laws as their liquefaction by direct application of heat. It is facilitated or retarded in the same way by great variations of pressure, and it is attended by the absorption of a certain amount of heat, which is given out when the dissolved body separates again in the solid state from the solution. Usually, also, the volume of the solution differs from the combined volumes of the solid substance and water at the same temperature. Solutions of salts also present the phenomenon of supersaturation analogous to that of the deferred solidification of water before mentioned. What is meant by supersaturation of solutions is this: When water, for instance, holds in solution as much of any salt as it can at a certain temperature, it is said to be a saturated solution at that temperature. As before stated, the higher the temperature generally, the larger the quantity of salt dissolved; it follows that if the temperature of a saturated solution be lowered some of the salt would separate from it.

If an aqueous solution of salt be boiled in a flask with a long, narrow neck, and this neck be hermetically sealed when all the air has been expelled, the solution frequently remains supersaturated when cold, but on breaking the point so as to readmit the air, even without shaking the solution in the least, it frequently crystallizes directly. It appears, however, that if the air that is admitted be previously passed through a red hot tube, or even if it has been merely filtered through a column of cotton wool, crystallization does not take place. It would appear from this that the unheated or unfiltered air contained some solid particles, which, by dissolving in the solution, disturbed its molecular equilibrium, thus causing it to crystallize. This seems to be confirmed by the fact that a supersaturated solution does not crystallize if stirred with a glass rod or platinum wire which has been recently made red hot, but crystallizes instantly if touched with a rod that has lain exposed to the air for some time. The absorption of heat during the solution of solids in water is taken advantage of to form freezing mixtures.

Thus a mixture of equal parts by weight of water and nitrate of ammonia at 50° F. will be reduced to 3°.2 F. by the solution of the nitrate in the water; and a mixture of 16 parts by weight of water, 5 parts of nitrate of potassium, 5 parts of chloride of ammonium at 50° will become reduced, when solution has taken place, to 10°.4 F.

As before stated, water boils under the ordinary pressure of the atmosphere at 212° F., a cubic inch of water becoming at this temperature nearly a cubic foot of steam.

Steam, when not in contact with water, is affected by heat in precisely the same manner as permanent gases; its rate of expansion and increase of elastic force are the same. When water is present, however, this is no longer the case, but, on the contrary, the elastic force increases in a more rapid proportion.

Water in becoming steam absorbs a large quantity of heat, which becomes latent, and is termed the heat of vaporization. This heat is again given out when the steam condenses to water. The latent heat of steam by one observer is 996°.4 F., and by another 998° F.

The latent heat of steam diminishes as the temperature of the steam rises, so that equal weights of steam thrown into cold water will have nearly the same heating power, although the temperatures may vary exceedingly. This also appears to be below the boiling point, so that to evaporate a given amount of water a certain quantity of heat is requisite at whatever temperature the evaporation is conducted. It is for this reason that distillation *in vacuo* at a low temperature effects no saving of fuel. The applications of steam are numerous; in some cases the heating power being required, and in others its elastic force is brought into use, as in the steam engine, &c., but this subject need not be further treated of on this occasion.

Sources of Water.

It is proper that we should give a description of the different sources from which natural waters are obtained, and also the properties of the water in each case. We will divide the several natural waters into rain, river, well, and sea waters, and, except the latter, the principal source of these is rain, snow, or hail.

It is probable that rain as it leaves the clouds is almost pure, but in its passage through the air it absorbs certain gases, and carries with it small particles of organic matter which are floating about in the air. The substances thus dissolved by the rain in its passage to the earth, *i. e.*, in the open country, are the gases, oxygen, nitrogen, and carbonic acid, a little carbonate of ammonia, nitric acid, this latter more especially after a thunder storm, it being formed from ammonia and water by the passage of the electric spark through the air. In or near large manufacturing towns several other substances are found in rain water, such as sulphurous acid, sulphuretted hydrogen, &c., varying with the kind of manufacture carried on near the spot. Again, if rain water is collected after having fallen upon the roofs of houses it will be further contaminated by various substances with which it comes in contact. Rain water from the absence of earthy salts is very soft, and on that account is, for some purposes, preferable to hard waters. Rain, after it reaches the earth, soaks down into it, and during its passage through the various strata dissolves certain salts, &c., the quantity and quality of which vary with the nature of the strata with which it comes in contact. When this takes place on high ground the water percolates the strata, and very frequently finds an outlet at some lower point, as a spring. One or more of these springs is generally the source of commencement of rivers, which, as they flow on in their course, become increased in size by the various additions of water received from rain, drainage from the surface of the earth, &c. The springs above mentioned generally yield hard waters, that is, water containing earthy salts in solution, the most frequent of which are carbonate of lime, carbonate of magnesia, sulphates of lime and magnesia, common salt, and organic matter. These are the substances which the rain, containing a considerable quantity of carbonic acid in solution, dissolves in its passage through the earth. Spring waters resemble well waters, and will be described more particularly further on. The river water, receiving supplies from those other sources which do not contain earthy matters, is, of course, softer than spring water. River water usually contains from 10 to 20 or 25 grains of solid matter per imperial gallon of 70,000 grains. The quantity, however, varies with the time of the year and the dryness of the season. The average compositions of the Thames and Colne waters are as follows, in grains per gallon:

	The Thames.	The Colne.
Carbonate of lime	13.308	15.835
" magnesia	trace.	trace.
Sulphate of lime	2.482	1.108
Chloride of sodium	1.622	1.677
Organic matter	3.250	1.830
	20.662	20.450

The above-mentioned substances are those most generally found in river water, the quantities per gallon and the relative proportions of the constituents varying according to circumstances. The hardness of water is generally determined by a solution of soap in proof spirit, made of such a strength that every degree of hardness shall be equivalent to one grain of carbonate of lime in a gallon. This simple method is known as Dr. Clark's soap test. The hardness before boiling of the Thames water above was 15°.13,[1] and that of the Colne, 16°.4.

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[1] Wanklyn, who somewhat modified Dr. Clark's method of registering degrees of hardness, made from 1873 to 1876 the following determinations of hardness of English potable waters:

	Degrees of Hardness.
London, New River Co.	15.0
London, Thames Co.	16.5
Leek town water	3.8
Leek Workhouse well	5.2
Oxton, Birkenhead	11.9
Chelmsford, Essex, town water	13.3
Cockermouth, Cumberland	2.5
Kirby Shore, Westmoreland	25.0
Chatham	24.0
Darley Dale, Derbyshire, well	7.5
Manchester water	3.0

Wanklyn states: "Suppose the question to arise, how much carbonate of lime is contained

In the above and similar waters the carbonate of lime is held in solution in the water by the presence of free carbonic acid. When the water is boiled this carbonic acid escapes, and the carbonate of lime is deposited; and it is this deposit which forms the principal incrustation in steam boilers. The removal of this carbonate of lime, or the greater portion of it, of course renders the water softer than before boiling. The hardness after boiling of the Thames water above was 6°.75, and that of the Colne, 6°.5.

If carbonic acid gas be passed through lime water until the precipitate first formed is dissolved the resulting liquid is a solution of carbonate of calcium in carbonic acid water. When the solution is boiled carbonic acid escapes, and the carbonate is again precipitated. Such an experiment will serve to show how chalk is kept in solution in ordinary well waters, giving the property of "hardness" and the manner in which the incrustation of boilers is formed. It may here be stated that sulphate of calcium produces similar hardness, and that these, with small quantities of the sulphate and carbonate of magnesium, constitute the hardening constituents of well waters.

Methods for determining the constituents and the degree of hardness of water will be explained in Chapter II.

The waters from wells differ from each other much more than do river waters, from the fact of the waters passing through different strata in different spots, and having no direct addition of rain water.

The wells in the different strata in and around London may be taken as fair examples. The water found in the wells in the gravel above the "London clay" is principally, or entirely, surface water, and often receives the drainage from sewers, church yards, &c., so that the composition of the waters from these wells differ greatly even in short distances; some of them containing only the ordinary constituents, carbonate of lime and magnesia, and sulphates of lime and magnesia, common salt, and a moderate quantity of organic matter, while others again are very impure, containing as much as 6½ grains of organic matter, 22 grains of nitrates produced by the

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by a gallon of one of these waters, the answer is found by subtracting one degree (which is due to the gallon of water itself). Thus, New River water contains 14 grains of carbonate of lime, or else other salts equivalent to 14 grains of carbonate of lime. The Cockermouth water contains only 1.5 grains of carbonate of lime, or salts equivalent to 1.5 grain of carbonate of lime, in the gallon."

oxidation of nitrogenous organic matter and salts of potassium. with the quantity of common salt greatly increased, and also frequently some ammonia formed from the putrefaction of nitrogenous organic matter. The nitrates would arise from organic substances which had passed into the water some time previously, and had had time to become oxidized by the air dissolved in the water, whereas the ammonia would arise from more recent contamination, and very likely putrefaction still taking place.

The pumps seen in the streets of London receive their supply from these sources, and are often placed close to church yards, from whence they receive the drainage, and hence the contamination.

From the decomposition of organic matter large quantities of carbonic acid are formed, and this being dissolved in the water, makes it sparkling and pleasant to drink. On this account these waters are deceitful and in hot weather dangerous, and upon the appearance of such diseases as cholera these pumps are closed.

The wells in the "London clay" are few and unimportant, the water being frequently bad and small in quantity.

The wells in the chalk and the sands above the chalk are the most important of all, from the large supply and temperature of the water, which is pretty constant all the year round.

These wells, of which there are a large number, vary from 300 feet to 600 feet in depth, but the water from all of them is of about the same composition. A remarkable fact about these wells is, that although the water comes from the chalk, there is scarcely any carbonate of lime or magnesia in it. the principal constituents being carbonate of soda, sulphate of soda, and chloride of sodium (common salt).

Sea water is a strong solution of salt, more especially common salt; but the water from various seas differ in composition, and even the same sea, as the Atlantic, appears to contain more salts per gallon, or to be a stronger solution, in the tropics than in the colder regions; this may be accounted for partly by the evaporation of water, which must take place in those climates. From the fact of containing so much salt in solution, its specific gravity is greater than that of fresh water, the general average being about 1.0274; hence its increase of buoyant power. The following analyses will show the composition of sea waters.

COMPOSITION OF SOLID MATTER IN 1,000 PARTS OF WATER.

	English Channel. Grains.	Mediterranean. Grains.
Chloride of sodium	27 060	27.220
" potassium	0.765	0.010
" magnesium	3.666	6.140
Bromide of magnesium	0 029	......
Sulphate of magnesia	2.296	7.020
" lime	1.406	0.150
Carbonate of lime	0.033	0.200
	35.255	40.740

The analysis of the water from the English Channel was made by Schwertzer, and that of the Mediterranean by Laurens.

The water from the Dead Sea differs greatly from other sea waters. It contains about 25 per cent. of saline matter, and has a specific gravity of 1.211. It contains a very large quantity of chloride of magnesium and chloride of calcium, besides chloride of sodium.

Ordinary sea water may be considered to contain, on the average, about 3.5 per cent. of saline matter, or about 250 grains per gallon, and is on this account unfit to drink.

THE EFFECTS OF WATER ON STEAM BOILERS.

We will now consider the effects of the several waters mentioned on steam boilers, when they are used in them continually. *Rain water*, from not containing earthy carbonates, would not form any incrustation in boilers, and the absence of salt would prevent its acting on the metal to a great extent. For stationary boilers no doubt it would answer very well, for the above reasons; but being so soft, it would be likely to boil too violently in locomotives, and would prime considerably.

River water containing carbonate of lime, held in solution by the presence of free carbonic acid, boils steadily, and is not likely to prime either in stationary or locomotive boilers. As the water boils the carbonic acid gradually escapes, the carbonate of lime at the same time being deposited in the insoluble state, and, in many instances, in a crystalline state. The slower it is deposited the more crystalline will it generally be.

In locomotives it becomes as hard as rock and is obliged to be chipped off. This incrustation also contains some sulphate of lime, sulphate of lime being less soluble in hot than in cold water, as before mentioned. This incrustation, which becomes fastened on to the iron of the boiler so tightly, gradually eats away a portion of the metal, for when chipped off the incrustation will have a layer of oxide of iron on the side which has been in contact with the metal. This incrustation, it is commonly stated, is a bad conductor of heat, and that when it is of any thickness makes a great difference in the quantity of fuel required to raise steam, and on this account it is claimed that a dirty boiler will not raise steam as quickly as a clean one.

We think that the evils of incrustation have been greatly exaggerated so far as increasing the quantity of fuel and time for raising steam are concerned; and, in fact, if the effects of incrustation were limited entirely to these drawbacks, which have been continually thrust forward on almost every occasion as those deserving paramount consideration, then we would feel that engineers and inventors of anti-incrustating compounds and apparatus had been battling with an almost chimerical drawback.

There now lie before me, as I write these words, the tubes which have lately been removed from a tug-boat; some of them were bound together by one solid mass of stone-like incrustation, which, when cut away, exposed portions of the tubes eaten and burned completely through; the shell of the boiler in some places was almost in the same terrible condition, being so thin after the incrustation was removed that a strong kick with the heel of a boot would crush it. The same engineer had been in charge of the boiler from the time it was built until it was removed from the boat, and had paid particular care in keeping the flues free from soot and ashes. A rigid examination of the record of the work that had been done by this boat, and a comparison of the expenses or rather the quantities of fuel which had been used, showed in the three years that the boat had been running only a small additional consumption of coal in the latter six months over that of the first six months of the period.

It is difficult to conceive that a boiler could be in a worse condition so far as incrustation is concerned, yet we find the increased consumption of fuel arising therefrom to be insignificant when compared to the loss caused by the destruction of the boiler, and the still greater extirpation that was momentarily impending to life and property.

The economy of fuel in generating steam is, of course, commendable, and, as we have before stated, should be constantly kept in view; but the tendency of the times is too often to lose sight of the greater evils in producing steam, and place undue importance upon those of lesser moment.

To speak plainly, for there is no excuse for mincing language in such matters, many persons having the care of boilers seem to think that their whole duty is performed if they can keep the engines moving, and have them develop the required power at a minimum expense for fuel. The plan would be good enough if it would only last; but suddenly there comes a suspicion, even to the most obtuse engineer, that even though there is no remarkable increase in the consumption of fuel, that it would be expedient to make a thorough examination of the interior of the boiler under his charge, and then he discovers that extensive repairs are necessary, and oftentimes that a new boiler is needed.

The great wonder is not that there are so many boiler explosions, but that there are so few.

But to return to our point of digression from which we have strayed further than was our intention.

As the water boils, and the steam is used, more water is continually added to the boiler to supply the place of that converted into steam. The carbonate and sulphate of lime being deposited during the process of boiling, the proportion of these in the water in the boiler does not increase to any extent; but such is not the case with the chloride of sodium (common salt). This being so very soluble remains in solution, and is, of course, gradually increasing in the water of the boiler until it is strong enough to set up a galvanic action between the metals where brass or copper comes in contact with the iron, as cocks, &c. The iron is the metal attacked, and, being gradually eaten away around the brass or copper, gives rise to leaks; the incrustation of carbonate and sulphate of lime having the same effect only in a less degree.

The accumulation of solid matters in boilers in this way is incredible to some people. Of course, blowing off the steam from boilers removes the sediment which is not so crystalline and which is not fastened to the boiler, and also the salt; but of this matter we shall have more to say in Chapters III and IV.

Well waters.—Those wells which yield hard water act upon boilers in exactly the same manner as river water; but, from the fact of their containing more solid matter per gallon, an equal quantity of these waters would yield a larger incrustation than river water.

The water from the chalk in the London basin, which contained the soda salts, answers well for stationary boilers, if the solution of salts is not allowed to get too strong before blowing off, otherwise they would set up galvanic action. The carbonate of soda already present renders it very soft and the small quantity of earthy carbonates are deposited as a fine powder.

This water will not answer for locomotives, as it boils so violently that it primes considerably, and in ascending a hill, wholesale, so much so that the engines run short of water much sooner than they ought to, and having to keep constantly adding fresh water to the boiler, to take the place of that blown out, steam cannot be properly kept up.

Well water containing a quantity of soluble salts acts upon the brass and copper to such an extent that boilers are almost covered in front with incrustations of salt; the boilers, of course, are greatly injured and rapidly destroyed.

Sea water acts in the same way on iron boilers, but being a stronger solution it requires no concentration before it begins to take effect, and must be frequently blown off.

PREVENTIONS TO CORROSION OF MARINE BOILERS.

Zinc has proved to be one of the most effectual materials for preventing the corrosion of marine boilers.

An examination of some steel marine boilers that had been in use for about three years showed no sign of pitting or corrosion in any of the parts. The boilers were washed out every voyage and very carefully examined. No zinc was used, but care was observed in washing out, drying out, and managing the water.

Some of the most prominent Liverpool engineers always use zinc for steel boilers, and take care to apply it most strictly by fixing slabs of zinc in various positions in the boiler, exposing not less than a surface of one square foot for every twenty indicated horse-power.

The zinc is usually found to be in a state of oxide and crumbling away in a comparatively short time. The whole is then renewed, and will last for a longer period when it is once more renewed.

Meanwhile there is no pitting or corrosion ; but on the contrary the interior surfaces appear to have taken a coating of oxide of zinc all over, and there is no trouble with them from corrosion.

Dr. Kossman states that zinc introduced into steam boilers to prevent incrustation proves very useful in case of selenitic waters, but as against the carbonate of lime, magnesia, and iron it is of little value, the zinc being soon rendered brittle and porous, and in a short time reduced to a powder.

Galvanic action, induced by the contact of zinc with the iron of the boiler, will, it is claimed, so long as the metallic contact is maintained, prevent corrosion of the interior of marine steam boilers.

The theory of zinc in contact with iron preventing corrosion may, as stated by Mr. King in an article in the Journal of the Society of Arts, be illustrated thus: "Take two pieces of metal, one of zinc and the other of iron, and immerse them in a solution of water diluted with acid, both will suffer from corrosion; but connect them with a wire, and you make them at once into a galvanic couple. A current of electricity is set up between them—the corrosion is directed entirely upon the zinc, which crumbles away, while the iron is no longer injured. The zinc is the positive and the iron the negative pole. Now you only have to continue the plate of iron till it extends all round the zinc and encloses it, and you have a perfect illustration of the manner in which an iron boiler, enclosing a block or mass of zinc, is made as a whole into the negative pole of a galvanic couple, and is thenceforward protected from corrosion."

It will also become evident that if the connecting wire be broken, or the contact between the zinc and iron made imperfect by the intervention of any foreign matter, the galvanic current will cease and the iron of the boiler will corrode as well as the zinc—just as the two pieces of metal were seen to corrode before they were joined by a wire.

It is claimed that carefully conducted experiments have proved that no mere mechanical attachment of the zinc will suffice to insure continued maintenance of the galvanic current, for no matter how carefully the zinc is fitted and secured to the iron, water will creep in, and a layer of oxide of zinc forming soon destroys the metallic contact.

It has also been found that the use of zinc plates is faulty ; if they are cast they soon split up and fall to pieces, and if rolled they are usually only about one-quarter of an inch in thickness and they soon dissolve away.

In order to meet the various defects in the use of zinc plates, Mr. James B. Hannay, of Glasgow, Scotland, designed a ball of zinc with a copper conductor cast through the center of it, the copper being so combined and amalgamated with the zinc at the junction of the two metals as to form brass, thus preventing the formation of corrosion between them to stop the galvanic current. This ball of zinc, which the inventor calls an "electrogen," is fitted in any convenient part of the boiler by a simple device, and from the moment the electrogen is connected to the boiler, it keeps up an uninterrupted galvanic current, and the interior of the boiler is protected from corrosion as long as any of the zinc remains.

The zinc is, by Hannay's invention, which was patented in England in 1881, and in the United States in 1883, applied in blocks or masses which are of a spherical, spheroidal, polyhedral or cubical form, or other form having but small difference of thickness in different directions, preference being given to the simple spherical form. Each sphere or block is by preference three inches, or more, in diameter, and has a wire metallically united to it, so as to extend to or beyond its center, the union being effected by casting the block upon the wire, or in some other sufficient manner. The wire, which may be of copper or of other suitable metal or alloy which is a good conductor of electricity, has its other end attached, by soldering or brazing or other equivalent means, to the shell or tubes or other part of the boiler which it is wished to protect from corrosion. The spheres or blocks are placed in the water in the boiler in any convenient situation, and are suspended or supported in any convenient way, but by preference not by means of the conducting wires. The blocks or masses of zinc are cast; but in order to render them more durable and efficient they are subsequently brought into the condition known as "malleable." For this purpose the masses are hammered or forcibly pressed or rolled, the operation being by preference effected suddenly. A convenient and satisfactory means for the purpose consists of a powerful screw-press fitted with a heavy fly-wheel or heavily-weighted arms and provided with suitably-shaped dies. The blocks or masses are by preference submitted to the hammering or compressing operation when heated to a temperature between 120° and 160° C. (248° and 320° F.) By a further improvement the zinc is made more susceptible of being rendered malleable by being alloyed with a small portion—say not more than ten per centum—of lead, tin, or copper.

Fig. 3.

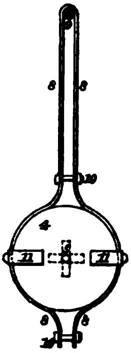


Fig. 4

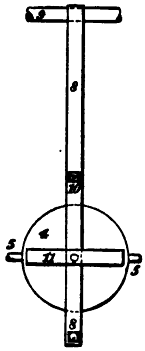


Fig. 6.

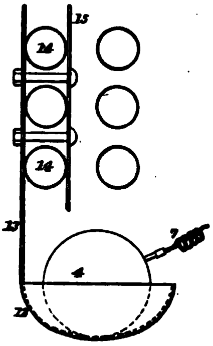
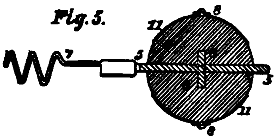


Fig. 5.



Figs. 3 and 4 are front and side elevations of a spherical block of zinc as suspended in a boiler, and Fig. 5 is a horizontal section. The sphere or ball 4, of zinc, is cast upon a brass core, 5, formed, by preference, as shown, with projections 6 radiating from the center. To one end of this core 5 there is soldered or brazed a copper wire, 7, the other end of which is soldered to the shell of the boiler. The ball 4 is suspended by means of an iron strap, 8, from one of the boiler-stays, 9, the ball being held or clipped between the lower ends of the strap 8 by means of screw-bolts 10, and by means of cross-pieces 11, riveted to the strap ends. Another mode of holding the zinc ball is shown in Fig. 6. According to this modification the ball 4 is simply placed in a ladle, 12, having a handle, 13, which is attached to some of the tubes 14 of the boiler by a clamping-bar, 15, and screw bolts.

A very good protection against the internal corrosion of a boiler consists of a thin layer of ordinary boiler-scale, and its value lies in its excessive thinness, otherwise it would soon crack by the expansions and contractions of the plates, and thus aggravate the evil of corrosion by retaining the moisture entering between the iron and the scale.

This scale is best given to the interior of the boiler before oxidation has had an opportunity to attack the iron surfaces, and should be formed as soon as possible after raising steam, the water in the boiler being kept at about three times the density of ordinary sea water for a short time in order to quickly produce the protective layer of scale.

Portland cement has sometimes been applied to the interior of marine boilers, and if it could be put on thinly and properly it would form sufficient protection against corrosion; but it is liable to be washed off by the feed, thus allowing particles to be carried over into the engine.

NOTE.—For a portion of the matter contained in this chapter, relating to the effects of water on steam boilers, the author desires to acknowledge his indebtedness to an excellent article on the subject by H. K. Bamber, and recorded in the Transactions of the Society of Engineers.

CHAPTER II.

DETERMINATION OF CONSTITUENTS AND HARDNESS OF WATER.

We cannot enter upon a full description of the different qualitative and quantitative methods for determining the constituents of water, but will only briefly describe a few examinations of importance, and refer those of our readers who may desire more minute information, concerning methods and apparatus employed, to the treatises of Wanklyn and Frankland on Water Analysis.

The qualitative examinations of water as to its admixtures of lime, magnesia, alkalies, chlorine combinations, sulphuric and carbonic acids, the larger or smaller quantity of which generally determines its character, can be executed in the following manner:

1. The chlorine combinations are shown by the formation of a white precipitate when treated with nitrate of silver in nitrate solution.[1]

2. Sulphuric acid and sulphates are recognized by the formation of a white precipitate with chloride of barium.[2]

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[1] Numerous apparatus containing chemical tests for water have been contrived, and without wishing to disparage such apparatus, it is probably best to state that without a knowledge of chemistry those who use them will be worse off with than without them. For instance, nitrate of silver is usually provided to determine the presence of chloride and chlorine; but if carbonate of soda should be present in the water under examination, carbonate of silver would be formed as well as chloride. Before the nitrate of silver could be applied the water should be aciduated with nitric acid to remove the carbonates, and then the nitrate of silver would throw down the chloride.

[2] 200—300 c. c. of clear water is heated to boiling, and then heated with a slight excess of solution of chloride of barium and a few drops of hydrochloric acid, boiled and filtered. The precipitate is washed, ignited, and weighed. Good filter-paper is essential for this determination.

3. Carbonic acid is present when the addition of clear lime-water gives a white precipitate.

4. The presence of silicic acid, lime, and magnesia, by evaporating to dryness, with an addition of hydrochloric acid, in a platinum dish of a capacity of about one litre. The residue is taken up with hydrochloric acid and water, the portion remaining undissolved being silicic acid. The lime can be separated as calcium oxalate from the filtrate with ammonium oxalate. After removing the calcium oxalate by filtration and evaporation of the filtrate, the magnesia is precipitated with ammonium phosphate, as ammonium magnesium phosphate.

5. Organic substances are shown by adding a few drops of potassium permanganate and some pure sulphuric acid. If organic substances are present the potassium permanganate, added drop by drop, is decolorized until all the organic substances are completely oxidized.

6. Determination of the entire residue. One litre is carefully evaporated to dryness in a platinum dish, the weight of which has been previously determined. The residue is dried at 356° F. until a decrease in weight no longer takes place.[1]

7. A determination of hardness with alcoholic soap solution serves in most cases as a substitute for a quantitative analysis. We give, therefore, a short description of it. The process of determining the hardness of water by a soap solution of a determined percentage, which was introduced by Clark, is a very simple one. By an addition of

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[1] It not uncommonly happens that the solid residue is exceedingly deliquescent; in such a case it must be rapidly weighed.

In order to give an idea of the amount of solid residue which actually occurs in natural water, we subjoin a few examples:

	Grains of total solids in a gallon.
London, Thames Companies	18.5
London, New River	17.6
London, Kent Company	26.5
Manchester Water Supply	4.7
Glasgow, Loch Katrine	2.3
Bala Lake	3.2
Guilford, New Supply	19.7
Scarborough Reservoir	28.7
The Rhine at Basel	11.8
Spree at Berlin	8.0
Atlantic Ocean	2688.0
Distilled water	0.1

soap solution to water containing too much lime or magnesia a white precipitate of lime or magnesia soap insoluble in water is formed as long as calcium or magnesium salts are present.

A distinction is made between "total hardness" and "permanent hardness." The hardness of water not boiled is termed total hardness, and the hardness produced by the earthly sulphates is termed "permanent hardness," because unaffected by ebullition; the term "temporary or changeable hardness" being also frequently used to denote the hardness produced by the earthy carbonates, because removable by ebullition.

The process of determining the total hardness is as follows: 50 c. c. of water are measured with a pipette into a bottle having a capacity of about 8 ozs., and provided with an accurately-fitting ground stopper. Before adding the soap solution the free carbonic acid is removed by shaking the water, and then sucking out the air from the bottle through a glass tube. Then add from a burette or pipette graduated into cubic centimeters 1 c. c. of a standard solution of soap,[1] shake the bottle vigorously, and repeat the process after each addition, the quantity of soap test being gradually decreased until it is added only drop by drop as the reaction approaches completion. When a dense, delicate lather is formed which will endure for the space of five minutes, the bottle being laid down on its side, then the operation is finished, and the quantity of soap solution must be accurately noted.

The number of cubic centimeters of soap solution required to produce a lather being known, the degree of hardness can be ascertained from Table No. 1 or 2.

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[1] *Standard soap solution.*—To make a potash soap, which keeps well, 40 parts of dry potassic carbonate and 150 parts of lead plaster (*emplastrum plumbi*, B. P.) are rubbed together in a mortar until thoroughly mixed. Methylated spirit is then added and titurated to a cream, and after allowing to rest for a few hours, transfer to a filter and wash repeatedly with methylated spirit. The strength of this is determined by adding it to 50 c. c. of standard calcic chloride solution (the preparation of which will be explained); proceeding as in determining hardness. Dilute with water and alcohol until exactly 14.25 c. c. are required to form a permanent lather with 50 c. c. of solution of calcic chloride. The water is added in quantities such as to make the proportion of water to spirit as one to two.

Standard calcic chloride solution.—This may be prepared by weighing 0.2 gram. of any pure form of calcic carbonate, such as Iceland spar, into a platinum dish and gradually adding dilute hydrochloric acid until it is dissolved; loss may be prevented by covering the dish with a clock glass. Excess of HCl is driven off by successive evaporations to dryness, with distilled water, then re-dissolve in distilled water, and make up to one litre.

1. CLARK'S TABLE OF HARDNESS—1000 GRAINS OF WATER USED.

Degree of hardness.	Measures of soap solution.	Difference for the next degree of hardness	Degree of hardness	Measures of soap solution.	Difference for the next degree of hardship.
Distilled water=0	1.4	1.8	9	19.4	1.9
1	3.2	2.2	10	21.3	1.8
2	5.4	2.2	11	23.1	1.8
3	7.6	2.0	12	24.9	1.8
4	9.6	2.0	13	26.7	1.8
5	11.6	2.0	14	28.5	1.8
6	13.6	2.0	15	30.3	1.8
7	15.6	1.9	16	32.0	1.7
8	17.5	1.9			

2. TABLE OF HARDNESS IN PARTS PER 100,000, 50 C. C. OF WATER USED.

C. C. of soap solution.	Ca CO$_3$ per 100,000.	C. C. of soap solution.	Ca CO$_3$ per 100,000.	C. C. of soap solution.	Ca CO$_3$ per 100,000.	C. C. of soap solution.	Ca CO$_3$ per 100,000.	C. C. of soap solution.	Ca CO$_3$ per 100,000.
.7	.00	3.8	4.29	6.9	8.71	10.0	13.31	13.1	18.17
.8	.16	.9	.43	7.0	.86	.1	.46	.2	.33
.9	.32	4.0	.57	.1	9.00	.2	.61	.3	.49
1.0	.48	.1	.71	.2	.14	.3	.76	.4	.65
.1	.63	.2	.86	.3	.29	.4	.91	.5	.81
.2	.79	.3	5.00	.4	.43	.5	14.06	.6	.97
.3	.95	.4	.14	.5	.57	.6	.21	.7	19.13
.4	1 11	.5	.29	.6	.71	.7	.37	.8	.29
.5	.27	.6	.43	.7	.86	.8	.52	.9	.44
.6	.43	.7	.57	.8	10.00	.9	.68	14.0	.60
.7	.56	.8	.71	.9	.15	11.0	.84	.1	.76
.8	.69	.9	.86	8.0	.30	.1	15.00	.2	.92
.9	.82	5.0	6.00	.1	.45	.2	.16	.3	20.08
2.0	.95	.1	.14	.2	.60	.3	.32	.4	.24
.1	2.08	.2	.29	.3	.75	.4	.48	.5	.40
.2	.21	.3	.43	.4	.90	.5	.63	.6	.56
.3	.34	.4	.57	.5	11.05	.6	.79	.7	.71
.4	.47	.5	.71	.6	.20	.7	.95	.8	.87
.5	.60	.6	.86	.7	.35	.8	16.11	.9	22.03
.6	.73	.7	7.00	.8	.50	.9	.27	15.0	.19
.7	.86	.8	.14	.9	.65	12.0	.43	.1	.35
.8	.99	.9	.29	9.0	.80	.1	.59	.2	.51
.9	3.12	6.0	.43	.1	.95	.2	.75	.3	.68
3.0	.25	.1	.57	.2	12.11	.3	.90	.4	.85
.1	.38	.2	.71	.3	.26	.4	17.06	.5	22.02
.2	.51	.3	.86	.4	.41	.5	.22	.6	.18
.3	.64	.4	8.00	.5	.56	.6	.38	.7	.35
.4	.77	.5	.14	.6	.71	.7	.54	.8	.52
.5	.90	.6	.29	.7	.86	.8	.70	.9	.69
.6	4.03	.7	.43	.8	13.01	.9	.86	16.0	.86
.7	.16	.8	.57	.9	.16	13.0	18.02		

Clark was the first to introduce the term "degree of hardness," and in Table No. 1 each measure of soap solution = 10 grains, and each degree of hardness = 1 grain, of carbonate of lime or its equivalent of another calcium salt, or equivalent quantities of magnesia or magnesium salts in 70,000 parts (= 1 gallon).

At the present time one degree of hardness is suitably estimated as equal to one part of calcium oxide in 100,000 parts of water.

Should it be found that the quantity of soap solution required to produce a permanent lather exceeds 16 volumes of the solution to 50 of water, a second experiment would be necessary. In such a case a smaller quantity of the sample of water—even as low as 10 c. c. if the water appears to be very hard—to which a sufficient quantity of recently-boiled distilled water has been added to raise the bulk to the required 50c.c. The same process is then performed as above described, but the number expressive of hardness must be multiplied by 2, or some other figure, according to the degree of dilution of the sample.

For the determination of the permanent hardness, 500 c. c. of water are gently boiled in a sufficiently large matrass for at least one and one-half hour, a part of the evaporated water being replaced by distilled water.

While the water is boiling the steam should be allowed to escape freely, and precaution must be observed to prevent the steam from the matrass from condensing and flowing back into the boiling water, because the escaping carbonic anhydride would be dissolved by the condensed water, which would thus be continually returned to the contents of the matrass in sufficient quantity to interfere with the complete precipitation of the carbonate of lime. The boiled water, when cold, is poured into a flask having a capacity of 500 c. c., and the matrass rinsed out with distilled water, the rinsing being added to the water in the flask. The latter is then filled with distilled water up to the mark and the entire contents filtered through a dry filter into a dry glass.

The degree of hardness of a definite number of cubic centimeters is then determined in the manner above described.

The English degrees of hardness are reduced to German by multiplying the degrees found by 4 and dividing by 5, the reduction of German to English degrees being *vice versa*, accomplished by multiplying by 5 and dividing by 4.

CHAPTER III.

PURIFYING WATER FOR STEAM BOILERS.

SECTION 1 —METHODS AND COMPOUNDS FOR PURIFYING NATURAL WATERS AND THOSE MIXED WITH THE DRAINAGE OF MINES, &C.

There have been proposed numerous methods for softening and purifying water, and if the incrustating ingredients could be removed from water before it passes in the boiler much inconvenience and expense and many boiler explosions would be avoided.

Clark's method for softening water is only applicable to water which owes its hardness entirely to the carbonates of lime and magnesia held in solution by carbonic acid, and which was described in Chapter II as "temporary hardness." But water which owes its hardness to sulphate of lime or sulphate of magnesia, "permanent hardness," cannot be thus softened; but any water which softens by boiling for half an hour will be softened to an equal extent by Clark's process.

The hard water derived from chalk, limestone, or oolite districts, is generally well adapted for this operation.

To soften 700 gallons of water, 1 oz. of quicklime is required for each part of temporary hardness in 100,000 parts of water. (See Table 2, on page 43.)

The lime is slaked thoroughly in a pailful of water, and the milk of lime thus obtained is stirred and immediately poured into the cistern containing at least 50 gallons of water to be softened, the heavy sediments being allowed to remain in the bottom of the pail. The bucket is then again filled with water, and stirred and poured as before.

If the rush of the remainder of the 700 gallons of water, which must be added or allowed to run into the cistern from the supply pipe, does not thoroughly mix the contents of the cistern, then it must be accomplished by stirring with a suitable wooden or iron paddle.

By the employment of a simple chemical test the proportion of lime may be more accurately adjusted. When a solution of nitrate of silver is added to water containing even only traces of uncombined lime, it strikes a yellow or yellowish-brown color. A dessertspoonful of the milky water should be from time to time taken from the cistern during the final running in of the water, and put into a white teacup containing a couple of drops of the nitrate of silver solution; if a brownish coloration results the slaked lime is still largely in excess, and more hard water must be admitted; should the milky liquid continue white after its admixture with the nitrate of silver, more milk of lime must be added to the water in the cistern; but if only a faint, just visible yellow tint be produced, then the proper proportion of lime to hard water has been attained, and the inflow of the latter should be cut off.

After standing for three or four hours the water will be sufficiently clear for washing purposes; but to render it clear enough for drinking, or for steam-boiler purposes, ten or twelve hours' settlement will be required.

Embree claims, that if a small quantity of quick-lime, either dissolved in water or otherwise, is put in common hard water, it will immediately seize upon the surplus carbon of the super-carbonate of lime, and reduce all the lime in the water to carbonate of lime, which being insoluble will fall to the bottom of the vessel, leaving the water pure and not liable to coat the boiler.

If the boiler be worked only in the day time, the lime may be placed in the cistern or well in the evening, and it is claimed that it will be settled before morning. The proper quantity of lime to be used the patentee states can be tested by litmus paper. Embree, also, in this patent, claims the use of "stillslop" to prevent or remove incrustation by lime in steam boilers.

By *Eames'* process the water, before entering the boiler, is heated by mixing with such decomposing agents that by contact the sulphates and carbonates will be rendered insoluble, and changed from a chemical to a mechanical combination with the water, or, in other words, will be no longer held in solution, but in suspension, and precipitation follows. In order to accelerate the precipitation of the decomposed calcareous matter, the water, after passing through the decomposing agents, and before entering the boiler, is filtered through a stratum of animal carbon or other filtering medium.

In the practical application of Eames' process, if the water to be used in the boiler has in it, in addition to the salts or calcareous matter held in solution by it, impurities such as grease, oil, dirt, or vegetable matter, it is first passed through a layer of animal carbon or sponges, or both, or through any other known and suitable process of filtration, in any suitable direction, as the nature of the case may require, to cleanse it of the impurities above named. The water is then percolated through a stratum of native carbonate of barytes (witherite) in powder or granulated, or in any other form deemed advisable, or through artificially prepared carbonate of barytes, either in powder or granulated, which barytes is to be confined in vessels of any suitable form that will best answer the purpose, in which vessels are to be placed wire gauze or other sieves to form inlets and outlets with or without supporting grating. The direction in which the water percolates through the witherite may be either horizontal, vertical, or angular, as may be deemed most advisable. The water is now passed through a layer of oxalate of barytes in a similar manner to that just described for the carbonate of barytes, after which the water is passed through another filter of animal carbon or sponges, or both. The water is thus claimed to be freed from all salts of lime or incrustating matter that it held in solution, and is ready to be taken by the feed-pump and fed into the boiler.

Degenhardt's process for purifying water for use in steam boilers consists in treating the water, preferably while it is in a feed-water heater, with sulphuric acid, in such proper quantities as will insure the desired effect, according to the degree of impurity contained in the water.

The sulphuric acid combining with the carbonate of lime converts the same into sulphate of lime, which will be precipitated and allow the pure water to be drawn into the boiler.

The test for ascertaining the purity of the water is as follows: Blue litmus paper is used, and immersed in the water to discover whether an excess of acid has been used, and red litmus paper is employed to ascertain whether all the carbonate of lime has been removed.

Dudley's process, patented August 21, 1883, consists in treating natural waters, before they are introduced into the boiler, with soda lime mixed in definite proportions, and the method of carrying the process practically into effect is substantially as follows: The water to be purified, having been analyzed to ascertain its chemical composition, is treated with soda lime in a powdered condition in such quantity as to combine with the carbonic acid in the water. The amount of soda lime required may be determined by the use of test-paper in the manner well understood; or, the causticity of the soda lime being known, a weighed amount sufficient to satisfy the carbonic acid, both free and as bicarbonates, may be added to the water. The proportions of the lime and soda in the soda lime used depend on the ratio between the carbonic acid, both free and as bicarbonates, and the sulphuric acid and chlorine in the water to be treated—that is, it should contain enough caustic lime (or its equivalent) to combine with the carbonic acid, both free and as bicarbonates in the water, and at the same time soda enough to combine with the sulphuric acid and chlorine in the water. For example, in a water having thirteen grains per gallon of carbonic acid, both free and as bicarbonates, and two grains each per gallon of sulphuric acid and chlorine, a soda lime would be required containing caustic lime (or its equivalent) and soda (Na_2O) in the ratio of five to one, or nearly so. After the soda lime has been added to the water and the same has been thoroughly agitated for an hour or more, it is allowed to stand until the mineral impurities have settled to the bottom. The clear water, it is claimed, may then be drawn off from the above precipitates for use.

The matter of agitation assumes special importance in the practice of this method, for the reason that the material to be diffused through the mass of water is introduced in the form of a powder instead of in solution.

A hot solution of caustic lime and caustic soda has been added to sewage waters for the purposes of purification, but the directions given in the specifications of the patent for that method would not enable natural waters to be successfully purified for boiler use. Furthermore, no statement is made that it is necessary to vary the proportions of lime and soda according to the water to be purified. With Dudley's process this is essential. One soda lime will not purify all waters. The foundation upon which Dudley's method rests is definite proportions between the soda and the lime.

But in the practice of Dudley's method, just described, it is found in purifying certain waters that so large an amount of sulphates, principally sulphates of soda and sulphate of magnesia, is left in the water that their presence becomes objectionable; and the object of the method which is now to be described and which was patented January 1, 1884, is to remove from the water the sulphuric acid in those sulphates, and such other mineral matter as may be precipitated by caustic baryta. In treating these waters, the method described in the patent of August 23, 1883, is exactly carried out until the completion of the agitation after the soda lime has been added, when caustic baryta is then added in sufficient amount to combine with the sulphuric acid of the sulphates. Agitation is then continued sufficiently long to cause the necessary reactions to take place. The water is then allowed to stand until it becomes clear, when it is ready for use.

In the practical application of the present method it may be necessary, in certain cases, to modify the constitution of the soda lime used as described in the patent previously referred to—that is to say, when the sulphuric acid is to be removed, it will not be necessary to have the soda lime contain enough soda to combine with the total sulphuric acid and chlorine in the water, but only enough to combine with the sulphuric acid and chlorine which in the original waters were combined with the lime. If a soda lime is used, however, which leaves carbonate of soda in the water, it will be necessary to add enough more caustic baryta to combine with this carbonic acid. The chemical reactions which take place as the result of the addition of the caustic baryta, as above described, are probably as follows: The water may contain the following salts which may be concerned in the reaction, namely, sulphate of soda, sulphate of magnesia, and carbonate of soda. By the reaction, sulphate of baryta, carbonate of baryta, hydrate of soda, and hydrate of magnesia will be formed. The baryta salts and the hydrate of magnesia will be precipitated and the hydrate of soda will remain in the solution. If chloride of magnesia has not been previously precipitated, its magnesia will now be precipitated by means of the caustic soda. The result of the whole operation will be that nearly all the mineral impurities occurring in the water, including the sulphuric acid, will probably be removed from it.

Dudley's Process of Purifying Waters, such as those Mixed with the Drainage of Mines, &c.

Certain waters—notably those mixed with the drainage of mines and pickling liquors from galvanizing works, &c.—contain such large amounts of corrosive constituents—such as sulphuric acid and sulphates of iron and alumina—that they cannot be used without great loss and damage to the boilers.

The object of the present method, which was patented January 1, 1884, by Dudley, is to render all these waters fit for use in steam boilers by removing the objectionable material from the water.

The method is carried practically into effect as follows: The water having been analyzed to ascertain its constituents, is treated with caustic baryta in sufficient amount to combine with the carbonic acid, both free and as bicarbonates, the sulphuric acid and the chlorine combined with lime and magnesia, iron and alumina, provided any or all of these are present. The water is then agitated for an hour (more or less) to effect thorough mixture and allow the remaining chemical reactions to take place. Carbonate of soda is then added in sufficient amount to precipitate, as carbonates, any lime or baryta salts that may be in solution in the water. This agitation is then continued sufficiently long to allow the necessary reactions to take place. The water is then allowed to settle, when the clear water above the precipitate is ready for use. The principal chemical reactions which take place in the above described method are probably as follows: The carbonic acid, both free and as bicarbonates, combines with the baryta, forming carbonate of baryta, which precipitates. The sulphuric acid combines with the baryta, forming sulphate of baryta, which precipitates. The chlorine will probably unite with the caustic baryta, forming chloride of barium, which will remain in solution. The carbonates of lime and magnesia held in solution by carbonic acid will be precipitated by the combination of the carbonic acid with the caustic baryta. The lime and magnesia, iron and alumina, combined with sulphuric acid, will separate as hydrates. Of these the iron, alumina, and magnesia will precipitate. The lime—at least a portion of it—will remain in solution. This caustic lime and the chloride of barium are precipitated as carbonates by the carbonate of soda.

Other reactions than those above given may take place, but the above are the principal ones; and the result of the whole, it is claimed, is that the largest portion of the objectionable impurities originally in the water are removed and the water rendered alkaline and fit for boiler use.

SECTION II.—APPARATUS FOR PURIFYING AND HEATING MINE AND NATURAL WATERS.

Shaw's Apparatus for Purifying Mine Water.

The object of Shaw's apparatus, shown in Fig. 7, is to enable the use of mine waters for steam purposes, and to prevent the corrosive action of the sulphurous and carbonic acid in the mine water upon the boilers, &c., in which it is used.

Fig. 7.

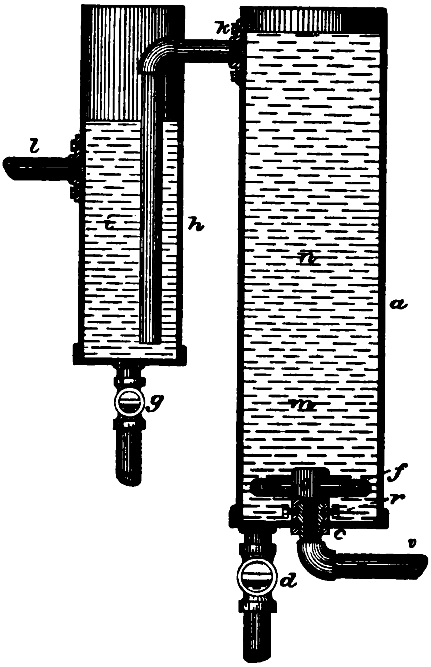


Fig. 7 represents a vertical section through center of two tanks, *a* and *h*, with the inlet-pipe *v*, for entrance of mine water from any source of pressure.

The water enters the two recoil arms *f*, which are simply metal tubes with their outer ends bent in opposite directions to cause the water to be injected in tank *a* at a tangent from the radius line, the effect of which is to rotate the arms *f* whenever the water is injected by external pressure. The recoil-arms *f* are secured to hub *o*, that revolves freely on boss-journal *c*, which is firmly secured to bottom of tank *a*. The screws *r*, secured to hub *o*, work in annular groove in journal *c*, or the screws can be screwed up tightly to prevent rotation, as desired.

d is outlet-vale for semi-fluids, and *k* is outlet for water free from acid into storage-tank *h*.

g is outlet-valve for any sediment in tank *h*, and *l* is outlet-pipe for purified water, to be used for steam and other purposes.

The tanks shown are supported in position by any of the ordinary methods of supporting tanks, and are given great length in a vertical direction to favor subsidence of solid matter.

The apparatus is operated in this wise: Ordinary burned lime is thrown into tank *a* in sufficient quantity to fill the tank one-quarter or one-fifth full when in a slaked condition. The mine water is forced through the lime from any source of pressure through pipe *v* and recoil arms *f*, the water being injected into the lime from the outer ends of the arms *f*. The lime dissolves by virtue of the presence of the water, and commingles with the water to a point half-way up the tank, the lime taking up all the sulphurous acid, forming sulphate of lime, and at the same time it takes up the carbonic acid, forming carbonate of lime. The sulphate and carbonate of lime being solids, they gradually subside or keep to the lower part of the tall tank *a*, permitting the pure waters to rise up between the solids and finally emerge, it is claimed, as clear water at the top, where it is permitted to flow off into a storage tank, *h*, through pipe *k*, which leads to the bottom of tank *h*, as shown, to prevent agitation of the surface of water in tank *h*, and to permit any further subsidence of solid matter that may come over in the tank by any undue agitation of water in tank *a*. The purified water *i* in tank *h* is drawn off by pipe *l* for steam or other purposes. The valve *g* permits the drawing off of any fine sediment in said tank *h*. When in the course of a day or longer operation the lime in tank *a* becomes saturated with sulphurous acid, it is drawn off by valve *d* and a fresh supply substituted. The rejected sulphate of lime can be used for agricultural purposes. The recoil arm *f*, when rotated by the action of the injected water, agitates the semi-fluid lime at the bottom of tank *a*, thus bringing new surfaces of lime in contact with the water. The same effect, in less degree, is caused by bolting the recoil arms in a stationary manner by screws *r*, when the injected water through the bent arms *f* produces a rotative effect upon the semi-fluid lime, agitating and rotating the same, bringing new surfaces of lime in contact with the water, which greatly facilitates the action of the lime upon the acids in the water, and, it is claimed, causes a more complete utilization of the lime.

Ralya's Water Economizer, Purifier, and Heater.

Rayla's device, shown in Figs. 8 to 11, is designed for use more especially in localities where well water or very hard water is used for steam purposes.

In many places, as is well known, the water is so much impregnated with lime and other substances which are injurious to boilers that it is almost impossible for that reason to use steam power ; and in

Fig. 8.

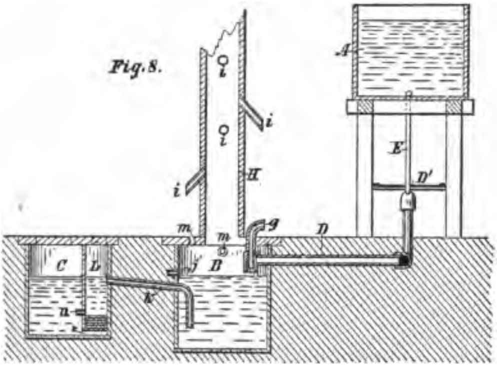


Fig. 11.

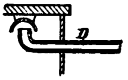


Fig. 9.

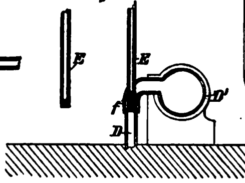
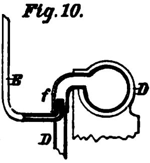


Fig. 10.



other places the supply of water, whether hard or soft, is so limited as hardly to warrant the use of steam. Ralya claims that by his invention he is enabled to overcome difficulties of almost any locality in regard to the impurities of the water from which steam is to be generated, and much of the difficulty incident to a scanty supply.

This inventor claims that by the use of his apparatus most of the water used is saved by condensation of the exhaust steam, and that the lime and other impurities are extracted from the water before it enters the boiler, and that the water is also highly heated before it is taken into the boiler, thus effecting a large saving in fuel.

Fig. 8 is a vertical section of Ralya's apparatus, illustrating his invention as adapted for localities where there are no water-works or elevated supply of water, and where, consequently, the water has to be pumped up; Fig. 9, a vertical section through the cylinder, the water-supply pipe, and the exhaust pipe; and Figs. 10 and 11 are modifications.

A is a tank, which may be supplied by pumping the water up from a well or from a stream; but such tank, of course, would not be needed where there is an elevated head of water at command, as in city water-works.

This tank should, of course, be sufficiently elevated to insure the proper fall of water which is to enter the exhaust pipe of the steam engine without forcing it in.

B and C are cisterns built in the ground, and may be made of brick and cemented with hydraulic cement, or of wood, or wood and iron, and of any suitable dimensions. The one, B, into which the steam is exhausted should be the larger of the two.

The water from the tank (or other supply, as the case may be) is introduced into the exhaust pipe D, which leads from the engine to the cistern A, at a point as near as practicable to the cylinder D′, and it enters it in the form of a spray, formed by a series of fine holes, *f*, made in the plugged or closed end of the supply pipe E, or in the side of the pipe itself, the end being plugged, the object being to jet or spread the water in every direction outward into the steam within the exhaust pipe, so that there may be a thorough intermingling or incorporation of the water with the steam. This shower or spray of cold water accomplishes two objects—viz: first, it condenses a large proportion of the exhaust steam; and, secondly, it takes up the heat that is lost or parted with by the steam, and becomes very hot indeed. This condensed steam and heated water are then conducted by means of pipe D into the first cistern, B, and it is discharged downward therein upon the surface of the water in such cistern, thereby heating the entire body of water and continuously acting to increase or to keep up a high degree of heat in the water, and at the same time, by striking the top or surface of the water, still increasing and continuing the further condensation of the steam.

The heating of the water sufficiently to cause a separation of all the impurities and a precipitation of the same can also be effected by simply letting the exhaust-pipe extend into the side of the cistern, and allowing the steam and hot water to escape horizontally therefrom, or by allowing this steam and hot water to escape upward or in any direction against a surface placed at right angles to the end of the exhaust pipe, or at any other angle that may accomplish the work of thoroughly intermingling steam and water, or by allowing the steam and water to escape upward or in any other direction into the mouth of a closed cap or bonnet, as shown in Fig. 11, and thus thoroughly intermingle the steam and water.

Again, the first cistern alone may be used, and the water taken directly from this cistern to the boiler, the mouth of the suction-pipe extending into the water to a point sufficiently below the surface to avoid using any of the greasy surface, and also sufficiently above the bottom to escape pumping into the boiler any of the separated and precipitated impurities, such as lime, &c.; and the filter can also be introduced into this first cistern. The inventor has used this method, but prefers the device in full, as shown in drawings.

A cold-air inlet-pipe, *g*, passing through the top of cistern or tank B, reaches down into the end of the exhaust-pipe D and terminates below its horizontal portion, but yet at a point above the outlet-mouth of such pipe D. The result of this construction is, that with the powerful exhaust of steam and water in the exhaust pipe, this cold-air pipe *g* acts as a strong air-pump, and with great force sucks in cold air at every exhaust of the steam, and thereby condenses the steam still more.

There is, as will be observed from the drawings, quite a considerable space between the water-line in the cistern B and the top of the cistern, and into this space inlets for cold air may be made for condensing more of the steam, and there is shown for this purpose a large wooden exhaust or vent stack H. This stack may be round or square, or of any other shape, but must be large enough to overcome any back pressure of steam in this cistern, and, in fact, to cause a vacuum or suction by its strong draft, and this really assists the engine and increases the condensation. Without this large stack there would be back pressure. This stack H is provided also with a series of cold-air inlets, *i i i*, and the draft of this stack would cause a constant current of cold air to enter the inlets, made as above named, into the top of the cistern. All of these points of condensation combined condense nearly all of the exhaust steam, so that the water is used over and over again, and always hot, and of course, therefore, all the fresh impurities must come only from the small amount of new and impure water that is introduced to take the place of the actual loss. The inventor employs air-inlets *m m*, either in the top or in the sides of the cistern B, to admit air into the cistern above the water-line, and in some cases these may be such that the inlets *i i* can be dispensed with.

The main difficulty hitherto in using the exhaust steam for heating water for the boiler has been that all the lubricants introduced into the cylinder have, of course, escaped into the tank with the exhaust steam, and this grease destroys the boiler in almost as short a time as the impure water, and sometimes is even quicker in its action.

It is also well known that the introduction of grease or oily substances into a boiler causes the water to foam, so that the attendant is unable to know actually how much water is in the boiler. The gage-cocks may indicate plenty of water when really the water may be dangerously low, and many explosions are caused in this way.

Ralya provides an overflow pipe, *j*, for running off this grease and acid from the surface of the water as often as it may be necessary, such pipe being located in the cistern wherever desired to perform this duty.

A pipe, *k*, connects the two cisterns B and C, and it has an elbow or downward bend, and is so located in the cistern, below the water-line and above the bottom of the cistern, that it never draws water from the surface nor from the bottom, and consequently neither the grease nor acid, nor any sediment or precipitated lime, nor any other impurity at either the top or bottom of the water in cistern B passes over to cistern C; but they are left in B to be removed therefrom at any convenient time.

In the cistern C the inventor placed a filtering vessel or compartment, L, provided near its bottom with gravel and charcoal or other appropriate filtering material, arranged in alternate layers or otherwise properly disposed, and the pipe *k* leads into this filtering chamber L, the lower end of which does not reach quite to the bottom of the cistern, or else must be provided with a sufficient outlet or outlets, *n*, to allow the filtered water to escape at the bottom into the cistern. This tends still further to purify the water before it is taken into the boiler.

Appropriate stop-cocks may be used as desired on the pipes.

The practical operation and results claimed for this apparatus are that the foulest water has its impurities extracted from it; that it is heated to a high degree in the cistern C, and after it has passed through the filter it is clear and pure.

The sediment can be readily cleaned out of the cistern B when required.

The apparatus, it is claimed, is economical of fuel, saving nearly one-half, and still more economical of water, saving nearly eighty per cent. of it; and the boiler is kept clean, as are also all the pipes and connections. The danger of explosions is materially lessened, which are so often due to overheating boilers when filled with scale. The life or durability of boilers is also lengthened by this invention, and there is also a saving of money, and in the labor of repairing and firing the boilers and engine. Besides the advantages claimed above, the apparatus is simple and cheap, and has no complex or intricate mechanism, and requires no specially skilled attendant.

Dervaux's Water Purifying Apparatus for Steam Boilers.

The object of Dervaux's apparatus, shown in Fig. 12, is that the water in steam boilers may be purified while the boiler is in operation, and this object is attained by combining with the boiler and feed-water apparatus a receptacle through which the boiler water is caused to circulate automatically and deposit therein the calcareous and other matters which it contains in suspension.

Figure 12 illustrates a sectional view of Dervaux's apparatus applied to the rear end of an ordinary steam boiler, G being the steam boiler and C C^1 C^2 the feed pipe, provided with a cock, *e*, and through

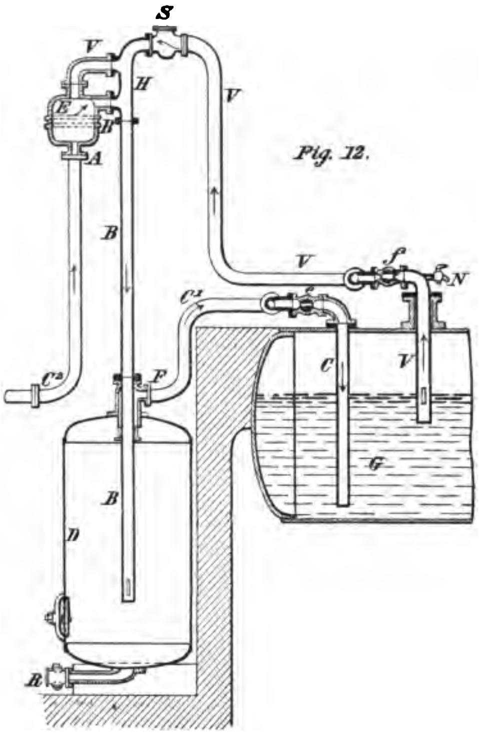


Fig. 12.

which water is forced into the boiler by means of a pump, injector, or other feeding apparatus.

The portions C^2 and C^1 of the feed pipe communicate with each other through a vessel, E, above the water level of the boiler, and through a pipe, B, and a vessel, D, below the water level. Connection is made between the portion C^2 of the feed pipe and the vessel E at A and between the portion C^1 and the extreme upper end of the vessel D at F, while the pipe B extends downward some distance into the vessel D, is preferably closed at its outer end, and is provided with an elongated lateral slot or solts near its end.

With the upper end of the vessel E communicates a pipe, V, the other end of which passes into the boiler, and is closed at its extreme end, but is provided with a lateral opening or openings extending between the highest and lowest points of the water level, the mean level being shown in the drawing.

The pipe V is provided with a cock, *f*, and preferably, also, with a check valve, S, opening in the direction of its arrow, while the inventor also prefers to make a direct connection between the pipes V and B through the pipe H.

The feed water, entering at A into the condensing vessel E, is forced to flow through the pipe B into the depositing vessel D, and thence through the feed pipe C^1 C into the steam boiler. Before leaving the condensing vessel E, however, the feed water is brought into contact with the steam, which rises through the pipe V from the boiler into the vessel E, and the consequent condensation of this steam produces a vacuum in the pipe V, so that the water in the boiler is violently drawn toward the vessel E. From the continued condensation of the steam of this mixture by the feed water the boiler water is drawn up into the vessel E and pipe H, where it unites with the feed water, and thence returns to the boiler through the vessel D, in which it will deposit the calcareous matters it contained in suspension. These impurities will settle at the bottom of the vessel D, and may be easily removed through the valved discharge-pipe R.

The suction or condensing chamber E and the decanting or depositing vessel D may be constructed in a variety of shapes, and may be combined so as to form a single vessel.

The vessel D may be placed at a level above that of the boiler, and be combined with a filter if desired.

An important point in the construction of the apparatus is to make the pipes V of the proper size, and to arrange the suction and condensing vessel E at a point sufficiently high, so that the feed water forced into this chamber shall condense as much steam, and consequently exhaust as much water from the boiler as possible. For the same purpose the suction pipe V is brought into direct communication with the pipe B by means of the connection H. Thus a portion of the boiler water, while drawn up with the steam, will be directly discharged into the pipe B without passing through the condenser E.

Instead of condensing the steam by bringing it into immediate contact with the feed water, the vessel E may be so constructed as to allow the steam to circulate on the external surface of the water chamber. The vessel E being, in this case, converted into a surface condenser, it will be advisable, in order to increase its heating surface, to make it multitubular, or in the form of a coil; or the vessel E may be made with a large cooling surface, so that the cooling will result from the outer contact of the atmosphere.

The pipe V may be open at its lower end, or the pipe may be arranged to extend laterally from the boiler, provided its opening extends between the highest and lowest water levels, so that the apparatus may operate, no matter how the water level may fluctuate. The pipe V may be provided with a test cock, N, in order to ascertain the condition of the water in the boiler.

Dervaux's apparatus may be applied to one or more boilers. In the case of a range of boilers, a single condensing vessel, E, and a single depositing vessel, D, will suffice, and it will be sufficient to provide one main suction pipe, V, which has the requisite number of branch tubes, each, however, being provided with a valve, *f*, so that each boiler may be purified separately. The apparatus may also be applied to automatic boiler feeders which are arranged above the boiler and connected with them through a steam pipe extending to the normal water level. These feeders being already partly adapted for the improvement, the inventor completes the apparatus by combining therewith a decanting or filtering vessel together with the necessary pipe connections and other devices, so as to assure the extraction of the calcareous matters from the boiler water.

In some boiler systems it happens that the impurities precipitated by ebullition in the intensely heated portions of the generator do not remain suspended in the water, but will settle in the less heated lower portions, from whence it would be impossible to extract them by circulation. In such cases, according to the construction of the boiler, a number of partitions may be arranged so as to prevent any descending current which might tend to start up in the interior of the boiler. By this means the precipitated matter is retained in the intensely heated portions and maintained therein in suspension by the ebullition of the water. Where the feed water is liable to produce incrustations, a disincrustant, such as carbonate of soda, may be used, by which the incrustations will be transformed into mud, so that it can be easily extracted from the liquid by this apparatus.

Elliot's Apparatus for Purifying Water for Boilers.

Elliot's invention, shown in Fig. 13, relates to an apparatus adapted to be placed in the interior of a boiler for the purpose of purifying the water previous to its use in the boiler.

It consists of a closed cylindrical settler having a drip funnel opening into the settler to receive the inflowing water, and an overflow through which the purified water escapes into the boiler. The settler has legs, which rest upon the tubes of the boiler, and the whole apparatus is placed above the water level in the boiler.

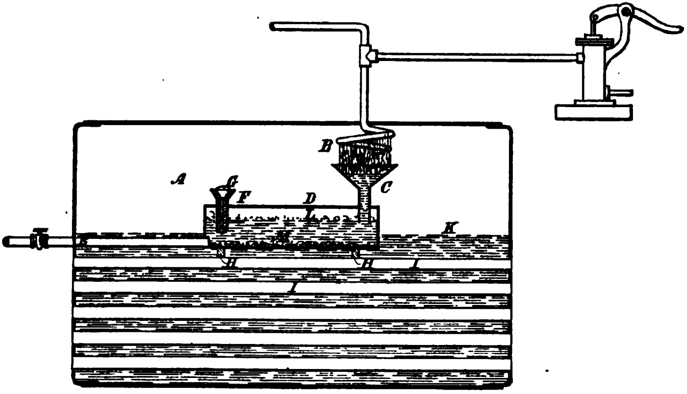
The body of the settler may be made square as well as cylindrical.

The water is introduced into the apparatus through a perforated spiral pipe at or near the top of the boiler, above the water line, and falls in a fine spray through the mouth of the flaring drip funnel into the settler, where it deposits its impurities. Such as are sufficiently heavy sink to the botton, while the lighter impurities float on the surface above the level of the interior opening of the overflow, which extends for some distance into the settler for this purpose. The purified water then escapes by the exterior mouth of the overflow, which is on a lower level than the mouth of the drip funnel. The sediment is removed by means of a blow-off adapted to the settler. A check valve in the overflow closes that opening when the blow-off is opened, so that the steam is caused to enter at the drip funnel and effect a thorough cleansing of the settler by traversing it from end to end.

It is necessary that the drip funnel should extend some little distance into the settler, in order to secure the air space inside the settler into which the impurities may rise. It should not, however, extend as far into the settler as the overflow. By spraying the water previous to its introduction into the settler it is exposed to the high heat of the boiler, and the depositing of its sediment greatly assisted.

In order to supply chemicals to the water in the settler, the inventor attaches a branch pipe to the feed pipe, through which the chem-

Fig. 13.



icals are forced by a force pump or other suitable means into the feed pipe, and thence carried to the settler.

In Fig. 13, A is the boiler; B the perforated spiral feed pipe; C the drip funnel; D the settler; E the blow-off; and F the overflow extending below the level of the water in the settler; G is the check valve; H H are the legs of the settler, resting on the tubes I I of the boiler; K is the level of the water in the boiler; L is the level of the water in the settler; and M that of the sediment deposit.

Previous to Elliot's invention we have known instances in which a branch pipe has been connected with the feed pipe of a boiler for the purpose of supplying matter to the water within the boiler to prevent the formation of scale in the interior of the boiler; but this is the first case that has come under our observation in which any such feed system for chemicals has been used in combination with a settler within the boiler, wherein the chemical action to purify the water takes place within the boiler, and thus secures the advantage of a high heat to precipitate the reaction, while the presence of the chemical is practically limited to the settler. Such would be the case where the chemical was added to hasten the deposit of the sediment.

Butman's Filter and Heater for Steam Boilers.

Butman's invention, shown in Figs. 14 to 17, relates to that class of heaters in which steam is introduced to raise the temperature of the feed water sufficiently to precipitate the matter held in suspension and to filter the same before introducing it into the boiler.

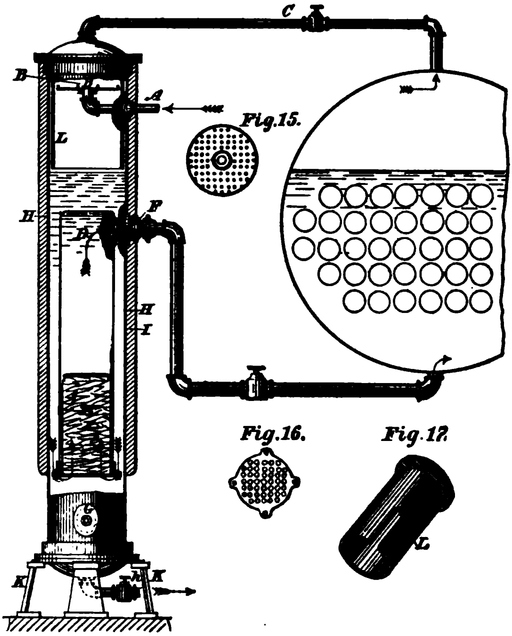
There is an outer casing inclosing an inner casing having a filtering apparatus at its lower end, a scattering or diffusing pan in the upper end, and connections to the boiler, with other details of construction.

It further consists in the combination of the outer cylinder or vessel having an upper and lower open end and adapted to be closed by detachable heads, and having a scattering or diffusing ring, as hereafter described, and arranged with an inner cylinder suspended or otherwise secured within the outer cylinder in such manner as to be readily removed for cleaning.

In constructing the inner and upper cylinder, L, the inventor prefers to turn a flange outwardly, so that it can be secured between the flanges of the outer cylinder and its head. This cylinder L is provided with a vertical slot in its side, which slips over the pipe A, so that when removed neither the joints of the pipe nor the diffusing ring is disturbed. The object of cylinder L is to prevent the calcareous matter separated from the water by the heat from depositing itself upon the surface of the main cylinder. When feed water that changes its condition by change of temperature is used, and the sediment held in suspension will readily separate by such change, the filter D may be dispensed with. The inventor's object is to precipitate in the purifier the impalpable particles which the feed water contains. The device is intended to act in conjunction with the ordinary feed-water heater, but may be operated independent of the same, particularly when a condensing engine is employed. In such case the water is taken directly from the hot well and delivered to the purifier by either pump or injector. When the water coming in contact with the live steam of the boiler is brought to a high temperature, the greater part of the sediment is precipitated, and that which is still held in the water is prevented from entering the boiler by filtering.

Fig. 14 is a view of Butman's device partly in section. Fig. 15 is a plain view of the scattering or diffusing plate. Fig. 16 is a view

Fig. 14.



of the bottom plate of the filter; and Fig. 17 is a detached view of the cylinder L, showing the elongated vertical slot.

H is the outer cylinder or casing, having a cover on its top, to which is attached the pipe C, leading to the steam-space in the boiler. Inside of the casing, and near the top, is an inner cylinder having a perforated scattering pan, B, attached to the water-supply pipe A. This pipe is connected with any well-known heater, or water is taken from the hot well of a condenser, by means of a pump, into the cylinder H. The cylinder is furnished with a hand-hole plate, G, and also a blow-off pipe and cock, *h*, for removing the sediment that collects in the bottom.

Within the cylinder or water casing H is an inner cylinder somewhat shorter than the outer one, and suspended thereto, about midway, by any well-known means. In the lower part of the inner cylinder is placed a filter, E. At the top of the cylinder D is the pipe F for connecting it with the water space of the boiler. The apparatus is set on legs or supports K, in such a position that the level of the water of the boiler will be a little above the inner cylinder D. The space above the water line is filled with live steam at boiler pressure through the pipe C.

The operation is as follows: The feed water being forced through the pipe A into an inner cylinder and on the pan B, escapes through the perforations in the pan, and falls down in a shower through the live steam, which raises the water to a higher temperature. Thence it slowly settles down to the bottom of cylinder H. The water then passes up through the filter E to pipe F, thence passes to the boiler; but under some conditions the filter D may be dispensed with. The water passes from the purifier to the boiler by gravity, and, owing to the large area of the cylinder, the current of the water is slow, allowing the impurities to settle in the bottom of cylinder H, which are blown off periodically, or removed through the hand hole covered by plate G. The filter may be separate and slipped into the end of the cylinder D. To clean the filter, the valve on the steam pipe C is closed and the blow-off valve *h* is opened, the pressure of steam in the boiler causing the water to be forced therefrom through the filter in an opposite direction to that in which it was fed to the boiler, thereby removing, if not all, a greater part of the impurities held by the filtering material which need not be renewed so often.

The covering I is of any well-known material, and extends down only to the bottom of the inner cylinder. The rest of the outer cylinder is exposed to the atmosphere in order to slightly reduce the temperature of the water, which causes the impurities to precipitate, and are blown off, as has been described.

Strong's Feed-Water Purifier and Heater.

In addition to the feed-water heaters and purifiers which have been described there are others, such as the valuable Stillwell heater and lime-extracting filter, manufactured by the Stillwell & Bierce Manufacturing Company, of Dayton, O.; the Argall, Bourgeois, Berryman, and the I. B. Davis, also Strong's heater and filter.

The object of Strong's invention, shown in Figs. 18 to 20, is to remove from water such impurities as carbonates of lime and magnesia and sulphate of lime, the water being thus rendered unobjectionable

Fig. 18.

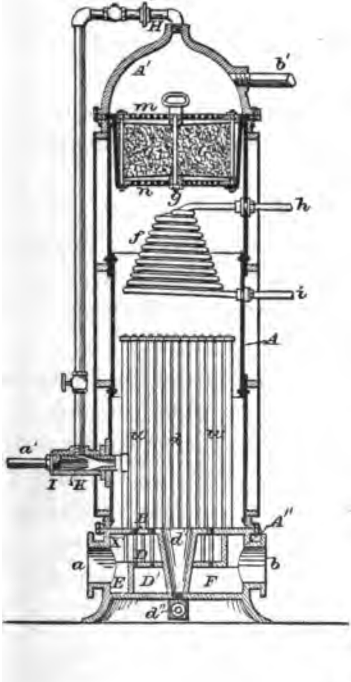
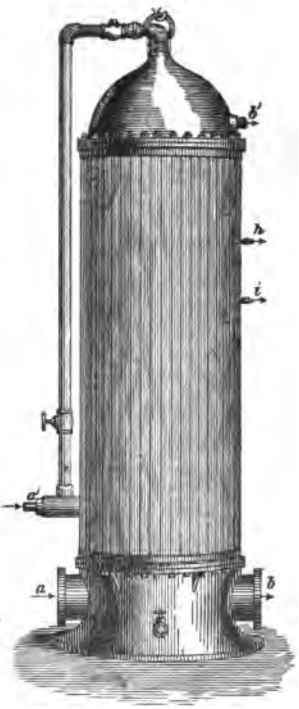


Fig. 19.



for use as feed water for steam boilers. When water containing such salts as those above mentioned is subjected to a high temperature the salts are converted into insoluble particles, which are held in suspension in the water, and can therefore be separated therefrom while this temperature of the water is maintained.

In carrying out his invention, therefore, Strong first heats the water to a temperature of about 250° F., thereby effecting the conversion of the salts into insoluble particles, the water, while so heated, being then passed through a filter, by which the insoluble particles held in suspension in the water are retained.

Fig. 18 shows a vertical section of Strong's feed-water purifier and Fig. 19 a perspective view of the same.

In Fig. 18, A is the cylindrical shell or casing of the heater, and to the upper end of this casing is secured the detachable cover A′, the lower end being secured to the base, to the peculiar construction of which one of Strong's improvements relates. The base consists of a hollow cylinder, A″, the three partitions B, D, and D′, and the central tube *d′*; the whole being cast in one piece, form a substantial base for the entire structure, and inclose the inlet chamber E and outlet chamber F.

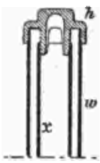
Exhaust steam is admitted to chamber E through the pipe *a*, and after making the circuit through the exhaust steam-heated pipes *d*, is discharged from the chamber F through the pipe *b*.

The central tube *d′* constitutes the blow-off passage, which extends through the whole of the partitions in the base, and forms a communication between the heating chamber and the blow-off pipe *d″*, this passage and pipe having no communication with either of the chambers E or F.

At the upper portion of the casing or shell of the heater is a mass, G, of filtering material—charcoal, for instance—which is confined between the upper perforated plate *m* and lower perforated plate *n*. A central rod, *g*, passes through both plates and through the filtering material, and has at the upper end an eye, to which, after the cover A′ has been removed, suitable hoisting tackle may be attached when the perforated plates have to be removed from the casing A with the filtering material, for the purpose of cleansing or renewing the latter.

A series of vertical tubes, *w*, pass through and are secured to the partition B of the base and communicate with the chamber E, and each of these tubes contains a smaller tube, X, the lower end of which is secured to the partition D and communicates with the chamber F.

Fig. 20.



The manner in which each external tube *w* is closed at the top and made to communicate with its internal tube is shown in Fig. 20, where *h* represents a cap screwed onto the external tube, and having a central tubular projection fitted into the internal tube and slotted or perforated at intervals, so as to form communications between the two tubes.

In a former method of constructing this heater Mr. Strong allowed the vertical tubes *w* to pass through the plates *m* and *n* and through the filtering material; but in the present improvement there is a space within the casing, between the lower perforated plate of the filter and the tops of the tubes, and in this space is the coil *f*, to which live steam is admitted at *h* and permitted to escape at *i*. This is an important feature of the invention, for the steam-heated coil increases the temperature of the water below the filter, and thereby reduces the water to the best condition for yielding to the action of the filtering medium.

The exhaust steam admitted to the chamber E must pass upward through the annular space between each outer tube and inner tube, and return through the latter, before it can reach the outlet chamber F, and hence a temperature nearly equal to that of the exhaust steam must be imparted to the water in the heater.

A pipe, H, extends from the upper end of the cover A′ to the chest I of an injector, feed water under pressure being discharged into this chest through a nozzle, K, and thence through the throat of the injector into the heater at a point a short distance above the partition B. The effect of this is two-fold: first, the introduction of the desired feed water into the heater through the pipe *a*′; and, second, an induced circulation of water from the top of the heater to the bottom of the chamber in which the series of coils *w* are placed. The water being heated by contact with the tubes *w* and the coil *f* before it reaches the filter, the foreign matter held in suspension is thus disintegrated. The pipe *b'*, which serves to convey the hot water from the heater to the boiler, terminates in the steam space of the latter, and the passage through the pipe is unobstucted by check valves, so that when it is desired to clean the filter G of the heater the valve of the blow-off pipe *d''* is opened and live steam allowed to pass from the boiler through the pipe *b'* and into and through the heater, the filter G being thus more effectually cleansed than by causing a backward flow of water through the same.

This apparatus is not absolutely necessary to the carrying out of Mr. Strong's invention, as various plans may be resorted to for raising the temperature of the water to the necessary degree before filtration, or in some cases a chamber in which the impurities can settle may take the place of filtration, as a means of separating from the heated water the insoluble particles held in suspension therein. But filtration is preferable with this heater, however, for obvious reasons.

In order to prevent the otherwise possible formation of scale, the means employed for heating the water should be such that the metallic surfaces will not be heated to a much higher temperature than the water.

A lower temperature than 250° F.—in fact, a temperature not much above the boiling point—is sufficient to convert the carbonates into insoluble particles; but the thorough conversion of all of the sulphate of lime held in solution by the water requires a temperature of about 300°. Chemically pure water, however, is so very seldom required, especially for such purposes as feed water, &c., that this extreme temperature will not generally be necessary; and Mr. Strong states that he has found in practice that a temperature of about 250° F. renders insoluble so much of the sulphate of lime present in the water that the quantity remaining in solution is not practically objectionable.

Strong's feed-water heater for locomotives consists, as usual, of an upright cylindrical vessel with a dome top, and it is located in the rear end of the fuel space of the tender. The heater has at the bottom a steam chamber, E, which communicates with the vertical heating pipes *d*, and above the latter are the live steam coils *f*, and the filtering material G, as shown in Fig. 18.

The exhaust nozzles of the locomotive have curved internal partitions, which serve to trap a portion of the escaping steam and direct it to pipes on the opposite side of the locomotive, these pipes being connected by suitable flexible couplings to pipes on the tender, and the latter pipes communicate with the steam chamber E of the heater, so that when the locomotive is in motion a constant supply of exhaust steam is introduced into the heater.

The blow-off pipe from the safety valve communicates with one of the pipes on the locomotive to which the flexible couplings are attached and leading to pipes on the tender, by means of a valve chest having a cylindrical valve and a suitable port. The tender carries a pump of which the discharge pipe terminates in a nozzle within a chest, which communicates with the interior of the heater and with a circulation pipe.

Live steam is conveyed to the heater through a pipe, *h*, and after circulating through the coils *f*, escapes through the pipe *i*. See Figs. 18 and 19.

Strong's feed-water heater for locomotives overcomes the objections arising from passing exhaust steam through the water in the tank of a locomotive tender for the purpose of heating the water prior to pumping it into the boiler, for when the water is heated by the latter method to a comparatively high temperature it is difficult to pump the water or convey it to the boiler by an injector. But with Strong's heater the pump acts upon the water before it is heated, and the feed water being maintained in the heater at boiling pressure, it will readily flow from the heater into the boiler when communication between the two is established. The additional advantages arising from the use of this heater on locomotives are the removal of most of the incrustating ingredients from the water, and in the economy of fuel.

Filters for Marine Boilers.

Feed-water filters have sometimes been fitted to United States naval boilers using high pressure of steam; in some cases they consist of a tank divided by screens into compartments, which contain substances for filtering the water or neutralizing fatty acids contained in it.

In *Selden's* filter the water as it comes from the hot well enters at the top of a tank and from thence passes through a vertical partition formed by wire screens encasing a sheet of Burlap cloth, which partition is placed in an upper compartment filled with coke, the plate forming the bottom of the compartment being perforated at one end with a number of holes, thus allowing the water to pass into the lower compartment, which is filled with sponge. Near the opposite side of the tank there are an equal number of holes in the bottom plate of the lower compartment, through which the water flows into the channel-way, where it is taken up by the feed pump. The compartments are provided with doors, through which the screens and filtering material may be removed, for the purpose of cleaning or renewing them.

CHAPTER IV.

ANTI-INCRUSTATION COMPOUNDS.

SECTION I.—GENERAL REMARKS.

The addition of decomposing or anti-incrustation agents, by introducing the same into the boiler, usually so increase the density of the water as not only to raise the boiling point to a higher temperature for any given pressure, but, in fact, commonly add to the evil they are designed to remove, by increasing the quantity of solid matter in the boiler, which consequently augments the amount of precipitable matter, and necessitates more frequent discharges of water from the boiler to keep the water at any given density. They also increase the liability of the water in the boiler to foam or froth over.

All sorts of compositions have been tried for preventing incrustation in boilers, but the majority are very costly and the benefit derived from them is not usually equal to the outlay, and it takes quite as much time to clean the boilers out when compositions are constantly used as otherwise. Some compounds increase corrosion while they prevent incrustation, and from the use of others practical difficulties arise which render their use inconvenient and dangerous. There are a large number of compounds for loosening and facilitating the removal of incrustation after it has formed; but there is probably no composition that will, with all waters, entirely prevent its formation. It is well known that a number of compositions that have been complete failures with some waters have yielded much better results with others. There can be no question that river, well, and spring waters greatly vary in different localities, and the remedy cannot, therefore, be constant.

If boiler compositions are used at all, care must be observed that they do not affect the metal of the boilers, and they must also meet the impurities and chemical properties of the water to which they are applied.

The unsatisfactory results obtained by boiler compositions are, to a great extent, carelessly multiplied owing to the lack of discrimination with which they are used.

In the usual way possibly a rough guess, but more probably not even the trouble to make a guess, is taken, as to the constitution of the water used, the boiler composition being ordered blindly and recklessly without reference to its nature or that of the water.

In addition to fixed mechanical and electrical devices, the following are some of the materials which have been placed in steam boilers to retain the mineral particles in suspension, or to prevent their adherence to the interior of the boiler:

Acids—
  acetic.
  hydrochloric.
  muriatic.
  nitric.
  oxalic.
  sulphuric.
Alcohol.
Alkalies.
Alum.
Ammoniacal salts.
Animal fats—
  marrow, etc.
Antimony.
Arsenical salts.
Ashes.
Barks in great variety, ground.
Barley-sprouts, malted.
Baryta.
Beeswax.
Black-lead.
Bone-black.
Bones, ground.
Borax.
Bran.
Broom-corn.
Burgundy-pitch.
Camphor.
Carbon.
Carbonates, in variety.
Caustic alkalies.
Cedar bark, extract of.
Charcoal, wood and animal.
Chestnuts coarsely pulverized.
Chlorides in variety.
Cider.
Clay.
Coal-tar.
Coffee-beans, roasted and ground.
Copper, salts of.
Copper scraps.
Copperas.
Cream of tartar.
Creosote.
Cutch.
Decoctions of bark.
Dextrine.
Divi-divi.
Earthenware, broken.
Eggs, whites of.
Eucalyptus, decoctions of.
Fatty oils.
Felt.
Fibrous materials.
Flaxseed.
Fruit.
Gambier.
Gas-tar.
Glass, broken.
Glue.
Glycerine.
Graphite.
Grasses in variety, fresh and decayed.
Gravel.
Gums in variety.
Hay.
Honey.
Horns, internal portions of.
Hydrocarbons.
Iron, salts of.

Iron scraps.
Isinglass.
Kerosene.
Lamp-black.
Lacquers.
Lead, salts of.
Leather scraps.
Leaves in variety.
Lime, milk of, and caustic.
Lime-paint.
Lime-water.
Linseed cake.
Linseed oil.
Logwood.
Lye, concentrated.
Malt.
Manure.
Meal
Metal, in strips or scraps.
Molasses.
Moss. Irish and other.
Mucilage.
Muriates, in variety.
Nut-galls.
Ochre.
Oils, in variety.
Oxalates, in variety.
Oxides, in variety.
Paints, in variety.
Paper, waste of.
Paraffine.
Peat.
Petroleum—
  crude.
  tar.
Phenol.
Phosphates, in variety.
Pitch.
Plants of various kinds.
Plumbago.
Pomegrate shells, dried.
Porcelain, broken.
Potash.
Potatoes.
Potato-starch.
Quicksilver.
Resins.
Roots.
Sal-ammoniac.
Salt, common.
Saltpetre.
Sand.
Saponavia.
Sawdust of various woods.
Shells, ground.
Shot.
Slippery-elm.
Soap.
Soapstone.
Soda—
  carbonate of.
  caustic.
  hyposulphite of.
  oxalate of.
  arseniate of.
  tannate of
Soda-ash.
Soot.
Sponge.
Starch.
Stones.
Sugar.
Sulphates, in variety.
Sulphur.
Sumac.
Tallow.
Tan-bark, ground.
Tan. spent.
Tanners' scraps.
Tannin.
Tar.
Terra-japonica.
Tin, salts of.
Tobacco.
Turf.
Turmeric.
Urine.
Valonia.
Varnishes.
Vegetable dyes.
Vinegar.
Voltaic devices.
White-lead.
Wood-fiber.
Zinc.

Some of the substances intended for the prevention of incrustation effect a chemical reaction, others act by a mechanical process, while others, such as oak sawdust, act both chemically and mechanically to prevent incrustation; the tannic acid which it contains forms tannates of lime and magnesia by the decomposition of the carbonates, and these tannates, on account of their low specific gravity, float about the water without forming any incrustation. The sulphates and chlorides are prevented from agglutinating into a crust by the mechanical action of the sawdust. Such anti-incrustation remedies as oil-cake, potatoes, and other starchy matter, glue, offal of hoofs and horns, tobacco-juice, Irish moss, peat, tow, hemp, &c., envelope the particles of lime and deposit them in the form of sludge; but such remedies, when introduced into boilers, always produce frothing and cause the water to foam badly.

Clay also precipitates the lime salts in the above manner, but cylinders, pistons, and valve faces are injured by the gritty particles of sand contained in it, and which are carried over by the steam. Tannic acid does not act upon sulphates and chlorides, and they will incrustate notwithstanding its presence in the boiler; neither is sulphate of lime altered by acetic acid, the action of the latter acid being to convert the carbonates into soluble acetates; but both of these acids attack the iron, and their presence in a boiler is dangerous.

Both tannic and acetic acid may be employed to purify water in tanks, provided, before the water is fed into the boiler, the excess of acid is neutralized by carbonate of soda. Sal-ammoniac does not affect sulphate of lime, its action being to convert the carbonate of lime and magnesia into chlorides, their carbonic acid passing to the ammonium and resulting in carbonate of ammonia, which mingles with the steam.

The injurious effects of sal-ammoniac on brass cocks and packings make its employment in boilers very undesirable. Carbonate of soda has, as a rule, given greater satisfaction in loosening old incrustations, and retarding the formation of new scale in stationary boilers, than any other material; but in locomotives it does not answer so well, as it causes the water to boil rapidly and thus to prime. In addition to being cheap and harmless in stationary boilers, having no injurious action upon the iron, unless the soda itself is impure and contains acids, it possesses the unusual advantage of rendering several services to the feed water at one and the same time, as it not only decomposes sulphate of lime and neutralizes any free carbonic acid present in the water, but carbonate of soda also causes the saponification of any greasy matter possibly present, the injurious effects of which before being saponified cannot be doubted. The result of the use of soda is to throw down in the form of sludge the materials which go to form the scale, the boiler being "blown out" frequently to remove the sediment.

A scumming apparatus, such as the Hotchkiss or an ordinary surface blow-out, have been found to be beneficial when soda has been used with greasy water.

It is not always easy to determine the amount of soda necessary to decompose all the sulphates of lime in feed water, and the proper quantity is best found by experience. In order to obtain the best results from the use of soda it should be dissolved and introduced with the feed water in small regular doses, rather than in large and infrequent quantities. The precaution necessary to be observed in the use of soda is to avoid an excess, which would act injuriously on the engine packing. Carbonate of soda is preferable to soda-ash, but is more expensive, the difference not being so great as at first sight it might appear on account of a larger quantity of soda-ash, which is impure carbonate of soda, being required, and then again it is less effective than carbonate of soda.

It is easy to understand that the reaction between the soda and the sulphate in the water takes place by the two salts exchanging their acids, and resulting in the formation of sulphate of soda and carbonate of lime, the first of which is very soluble, and the latter, being absent from carbonic acid in excess, is insoluble, and in precipitating does not form a stone-like incrustation.

The same result, *i. e.*, the precipitation of lime salts, is produced by the reaction on the bicarbonate of lime contained in the feed water. The carbonate of lime is rapidly precipitated by the soda salt seizing upon the carbonic acid in excess. But the heat again sets free the carbonic acid taken up by the alkaline carbonate, and the soda being then in its pristine state, acts again as before, and this probably is an explanation why a large quantity of water is acted upon so effectively by a very small quantity of soda.

The carbonate of lime, after settling, which it quickly does in the quietest part of the boiler, remains for the most part as a sludge that can be easily washed out, as has already been stated. Before settling, this precipitate, in consequence of its minute division, is carried by the agitation of the water to the surface, and remains for a time as a scum, although the specific gravity of the solid carbonate is about 2.7. For the above reason, when lime salts are present in any considerable quantity, the use of soda should always be accompanied by frequent and regular blowing-out, to prevent foaming and the overheating that is liable to take place from the thickening of the water, or from the settling of a large quantity of deposit on the furnace plates when the water is allowed to become quiet, as at meal times.

The plan of drawing the fire at the end of the time on Saturdays and at once blowing off all water and steam from boilers is not a good one, and it should not be practiced.

As soon as the boiler is empty, the plates and brick work, being still hot enough, bake the sludge into a hard incrustation along with the sulphate of lime usually found with it, which otherwise would be quite soft and more easily removed.

It is simply a question of time, when the shell of a boiler is constantly rapidly cooled, as to when it will crack.

It is not an uncommon thing for some engineers, who ought to know better, to draw their fires, and in a few minutes afterward "blow out" the boiler, and as soon as empty fill at once with cold water, in order to "cool them quickly," but the practice is unsafe. No wonder they find a cracked sheet occasionally, and find it necessary to put on a patch.

The best plan is to draw the fires after the work is done, close damper and ash-pit doors, also fire doors, and let everything remain until morning The water can then be allowed to run out of the boiler, the manheads can then be knocked in, and a few spurts of pump or hydrant hose will allow one to go inside and brush out the loose scale and examine the interior. In following this plan, the incrustation will be found to be much softer and more readily removed, and five minutes' use of the hose will wash out all the soft mud that may remain on the bottom and sides of the boiler. The boiler by this plan of allowing the steam to condense over night will cool slowly, and will be less likely to crack the sheets.

Another plan and composition is to take for every ten horse-power two gallons of oak-bark tan liquor, one quart of common molasses, and two ounces of bicarbonate of soda, and after mixing, the compound is poured in while the boiler is empty, and then ten or twelve pounds of steam is raised, the boiler is then allowed to cool down, the manheads removed and the scale cleaned out. We have seen this method used on a large number of foul boilers, both land and marine, with excellent results.

"When it is intended to scale a boiler it should be entered as soon as it has sufficiently cooled off, for the scale can be removed more readily while it is still damp than when dry. When there is only a thin scale in marine boilers, such as has been described on page 38, it should not, of course, be disturbed.

"The scale on the plates is chipped off with scaling-hammers or wedged off with scaling-bars, but the chipping must be carefully done, and all indentations in the surface of the iron and injury to the rivet-heads should be avoided, and therefore the tools should not be ground to a sharp edge, as all indentations in the iron make it more liable to be attacked by corrosion.

"The plates between the rivet-heads, at the edges of laps, and around the crow-feet, or the heels of braces, should have the scale removed most thoroughly.

"Sometimes the vertical spaces between the tubes can be freed by running a scaling-bar through them; but when the accumulation of scale on the tubes becomes excessive a sufficient number should be removed to make the remaining tubes accessible. The braces should have the loose scale knocked from them; the mud and rust must be thoroughly scraped from the shell of the boiler in the water and steam spaces, special precaution being observed that none of the material lodges between the tubes or on the furnace crowns. The dirt is then raked with small hoes out of the bottom of the boiler.

"Finally, the boiler is to be thoroughly washed out, which can be done by means of a hose connected to a force-pump, by directing a heavy stream of water at every portion of the interior of the boiler, especially at such parts as are not accessible for scraping.

"By this means much loose scale and mud will be washed down. Commence 'the washing' out in the steam space, directing the jet of water especially into the steam drum and into the water spaces around the back connections. Then take the hose in succession to each manhole over the furnace crowns, and finally, into the mud holes at the bottom. During the operation of cleaning marine boilers a slight list is given to the vessel, so that the water will naturally flow to the front of the boilers, carrying the dirt along with it, and the fire-room floor-plates in front of the boilers are removed to allow the water to run directly into the bilge of the vessel.

"After the boilers have been washed out and all the water removed from the bottom by raking and swabbing, the boiler must be kept open till it is perfectly dry in every part. Pans with burning charcoal may be placed in the furnaces and connections to dry the boiler more rapidly."

Sometimes the inside of boilers is washed with a mixture of grease taken from the shaft bearings and oil of tar from the gas works, which renders the scale more easily removable, though it does not prevent its accumulation. Much care is necessary in the use of grease, as explosions have been caused by the accumulation of greasy matter in boilers, overheating of the plates having been caused thereby. It has been found that the use of tallow prevents priming in low pressure marine boilers, but increases it in locomotive boilers, and the explanation probably is that in low pressure marine boilers, where the water is salt, the salt spreads on the surface and causes priming, but a little tallow prevents the salt from spreading, and thus stops priming. In land boilers of course no one uses salt water.

"It has generally been supposed that a deposit in a soft state caused little or no injury to a boiler, but the contrary is true. The impalpable powder found in a boiler, when empty and dry, often is mainly carbonate of lime, and on account of its lightness it is long held in suspension. When the water, from constant evaporation and little or no blowing, is rendered unfit for generating steam on account of the resistance offered to the free convection of heat, a deposit of slush or sludge collects on the bottom, around the seams, and in fire-box boilers around the furnace sheets and in the water legs. Its presence is detected by leakage at the seams, fractures at the edge of the plates, and in the line of rivets, and by overheating and consequent depressions of portions of the plates where it rests.

"This difficulty is greatly aggravated if grease finds its way into the boilers; the grease appears to combine mechanically with the carbonate of lime, and sinks on the plates when the boilers are at rest. It becomes a loose, spongy mass, which is not carried off by the circulation, but, by its contact with the plates, causes overheating and burning."

There often are made wholesome recommendations of the use of oil in boilers for the purpose of removing and preventing the formation of scale; but it is very evident from the above that those who make such representations possess but little knowledge of the different qualities of oil, for most oils, especially those employed for lubricants, are very damaging when they are put inside of steam boilers. Many of the oils used on engines for instance are compound oil, that is, they are a mixture of earth or rock oil, tallow, resin, whale oil, plumbago, fish oil, beeswax, &c., the latter substances being mixed with the rock oil to give it body. The volatile portions of course quickly pass off with the steam and do but little harm. The more solid portions and grease, however, are left behind, and by keeping the water from contact with the iron of the flues and lower portion of the shell of the boiler, the tubes thereby become distorted and leak around the ends, and the fire-plates bag down and greatly weaken the riveted joints.

Crude petroleum may often be used to loosen the incrustation in steam boilers, and on this point we shall have more to say in Section II of this chapter, where is given an account of Allen's process for employing crude petroleum.

SECTION II.—BUZBY'S, AUER'S, TEMPLE'S, SPANNAGEL'S, GANSZ AND LAVO'S, THOMAS', HAUXHURST'S, ALLEN'S, FISHER'S, PITTS', CLEGG'S, HOLDEN'S, TAYLOR'S, HEIMANN'S, WISHART'S, NORTH'S, AND BACON AND QUEEN'S COMPOUNDS AND PROCESSES FOR SOFTENING, REMOVING, AND PREVENTING THE INCRUSTATION OF STEAM BOILERS.

Buzby's Compound.

Buzby claims that if about five pounds of bark from the sweet gum tree be made into a decoction by boiling in water and ten pounds of gambier be added to it, and the whole boiled until the gambier is dissolved, that the compound will, if introduced into a boiler, loosen the scale, and that if its use be continued the formation of new scale will be prevented. The quantity per horse-power to be employed is not stated.

Auer's Compound.

Auer claims the following compound to loosen and remove the incrustation from a 10-horse power boiler:

Gum catechue..........	½ lb.
Common salt............	3 lbs.
Saltpetre.................	½ lb.
Flaxseed, ground......	1 lb.

The whole to be finely and thoroughly pulverized and mixed together in a uniform mass.

The dry mixture may be thrown into the boiler any time when the steam is not up, or, if preferred to apply the mixture in a fluid state, a sufficient quantity of water may be added.

It is claimed that this mixture loosens and softens the scale or incrustation, so that it may be readily blown out with the steam.

The proportions of the ingredients are of course increased in accordance with the size of the boiler.

Temple's Compound.

Temple claims that the following composition is effectual for the removal and prevention of incrustation in steam boilers: 13 pounds of the ordinary terra japonica of commerce being placed in a suitable vessel with water, the whole is brought to a boiling heat until the terra japonica is dissolved. The mixture is then strained while hot. Then dissolve 3 pounds of statice root or marsh rosemary in water, and boil and strain it in the same manner as the terra japonica. The composition presents the consistency of a sirup. The quantity to be applied per horse-power is not stated.

Spannagel's Compound.

Spannagel claims that the use of the following composition will, if used with the water before it enters the steam boiler, clear it of incrustating ingredients:

Proto chloride of iron	30	parts.
Murias stoutia	30	"
Barita murias	15	"
Acetate of protoxide of iron	15	"
Terra japonica	5	"
Ammoniac murias	3	"
Brown sugar	2	"

The water, before it is supplied with this composition, is brought into a reservoir where the compound, first having been finely pulverized, is added at the rate of 1 pound for as much water as will be required for an engine of 100 horse-power during the time of twelve hours.

Gansz and Lavo's Compound.

Gansz and Lavo claim that the following compound will remove old incrustations from boilers:

Chloride of iron	10 lbs.
Chloride of barium	5 lbs.
Sal ammoniac	1 lb.
Rectified sugar	4 lbs.
Concentrated lye	4 lbs.

When the compound is prepared it is well mixed and kept from the air, as it is exceedingly volatile. About 1 pound of the mixture is each morning put into the cold-water reservoir or heater for every 500 gallons of water used in a steam boiler.

Thomas' Compound.

Thomas, for removing and preventing the formation of incrustation in steam boilers, claims that a compound in the proportion of 1 pound of extract of hemlock bark and 2 pounds of corn meal is effectual. He mixes the ingredients either by grinding them together or by reducing the extract of hemlock bark to a fine powder, and straining it with the corn meal, or the extract may be used in a liquid state and mixed with the corn meal, so as to form a paste, which can be conveniently introduced into the steam boiler, or, if desired, each of the ingredients may be introduced separately.

Hauxhurst's Method of Preventing the Incrustation of Marine Boilers.

Hauxhurst claims that the use of lime water will prevent the rapid destruction of boiler tubes in sea-going steamers using surface condensers.

The lime water may be introduced at intervals, as required, or it may be continuously, in small quantity, by mechanism provided for that purpose; or it is perhaps preferable to use a globe cock similar to the common globe talon-cock used on steam engines.

One pound of lime per day of twenty-four hours for each 150 horsepower developed in usual practice, is stated to be a fair criterion for the engineer to gauge the quantity to use, taking care to use too much rather than too little.

Allen's Process.

Allen's process for softening and removing incrustation consists in introducing a quantity of crude petroleum into the boiler by pouring it through the safety-valve or any available opening after the water has been blown off and the boiler cooled. As the water flows into the boiler the petroleum rises with it, and is brought in contact with the entire inner surface of the shell.[1] When the water has reached the desired altitude the fire may be applied and steam raised as usual.

The petroleum may be applied in different ways; for instance, the interior of an empty boiler may be washed over with the material, or a coating of paraffine may be applied prior to the introduction of water. The quantity of petroleum to be used depends upon the condition of the boiler. Refined oils may be used or any of the hydrocarbons or mineral oils, whether they be obtained from wells or by the distillation of bituminous coal, shale, &c.

Fisher's Process.

Fisher's process consists in covering the bottom of the boiler with quicksilver. Thus by interposing a liquid metallic medium between the water and heated surface, he claims that incrustation will be prevented not only at the point covered by the liquid, but that the entire interior surface will be kept clean and free.

Pitt's Compound.

Pitt's compound may be prepared as follows: Take of leather scraps or cuttings 3 pounds, by weight, caustic soda one-fourth of a pound, and add thereto 1 gallon of water; boil the whole in a suitable vessel, say of copper, until the leather scraps are thoroughly dissolved; then add to the solution one-quarter of a pound of glue, gelatine, or isinglass, that has been previously steeped in cold water for a space of twenty-four hours, and incorporate the several ingredients well together; the mixture being introduced into the water of a boiler, in any suitable quantity. (See the next compound.)

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[1] Hard scale may be often removed in this way which it would be difficult to clean out of the boiler by any other process. Crude petroleum is volatile, and the amount of residuum which would result from the quantity used in a boiler for such purposes would be so small as to be harmless. But the indiscriminate use of crude petroleum is, however, not advisable, for if the water contains organic matter, or is liable to be muddy, there are other purgers which will be better. Crude petroleum is most effective for hard lime scale. By introducing the oil cold in the manner above described, it washes the incrustation as it rises with the water, and by penetrating and rotting the scale it finally works its way between the incrustation and iron of the boiler, thus detaching it in the same manner that it does when petroleum is used to aid in removing a nut from a rusted bolt, the rust or oxide being dissolved by it without injuring the iron.

Cryer and Norris' Compound.

Cryer and Norris' compound, which is an improvement on the one above described, patented by Pitts, consists in a preparation of prepared leather scraps with caustic or hydrate of soda, the leather scraps being first submitted to a preliminary treatment by which they are freed from all such extraneous matter as grease and oil.

The great objection to Pitts' compound is that the soda liberates from the leather the oil, grease, &c., with which it has been originally dressed, and forms with it a saponaceous compound, which causes the water in a boiler to foam, so as to greatly interfere with or stop its proper action.

Cryer and Norris contemplate the preliminary treatment of leather scraps with naphtha or other volatile oil or substance, by which all the oil and grease is removed from the leather, then drying it to remove all the volatile oil, and lastly, boiling the leather scraps in caustic soda until dissolved, and the addition of a sufficient quantity of water.

In carrying out their process they take the required quantity of leather scraps to make the proper proportion of the compound and steep them in naphtha or other suitable hydrocarbon, or volatile oil or substance, which will remove from them all grease and oil which may be in them. After this is accomplished the leather scraps are removed from the liquid, and spread in a suitable place to dry; after the leather scraps are dry or freed from the volatile oil they are placed in a solution of caustic soda or hydrate of soda and boiled until dissolved. Various proportions of the substance named may be used; but 1 pound of the prepared leather scraps to 2 ounces of hydrate or caustic soda and 1 gallon of water it is claimed will produce a compound which gives very satisfactory results.

In some cases tan-bark is treated by boiling with hydrate or caustic soda and the resulting liquid added to the compound ; but this is not absolutely necessary, although for some purposes it is claimed that it improves the compound.

Clegg's Compound.

Clegg patented the following compound for removing the scale and other deposit from steam boilers ; it is mixed with the water in the boiler, and consists in a mixture of 10 parts of bone black, 7 parts of sulphate of copper, 60 parts of soda-ash, and 23 parts of black oak bark. To prepare the compound, take the ingredients separately, and, after reducing them to impalpable powder, mix them thoroughly together with or without the addition of a small quantity of water. The compound is now ready for use, and may be mixed with the feed water or introduced directly into the boiler. The effect claimed for this compound is that it loosens and detaches the scale from the boiler surfaces and does not reduce the scale to a powder by a lengthy process.

About four ounces of this compound is used for each 1 horsepower of the boiler.

Holden's Method.

Holden's method for preventing the formation of incrustations in steam boilers consists in the application to the iron of a compound of metals which are electro-positive and electro-negative in relation to iron, as a positive metal and a negative metal attract and protect each other.

This alloy the inventor attaches to the iron at convenient points, somewhat distant from each other, by applying it in the form of rivets or bolts inserted in various portions of the boiler, or in the shape of rings, bands, or plates, which are hung upon the tubes or flues of the boiler or otherwise fastened to the structure in any convenient manner.

The alloy consists in a compound of zinc, from 33 to 50 parts by weight; tin, 33 to 50 parts by weight; lead, 1 to 10 parts by weight, and antimony, 1 to 10 parts by weight. These are combined by melting them together, or by melting separately, and mixing the same, forming a homogeneous metal.

To make a compound of these metals which shall be homogeneous, proper fluxes must be used, and care exercised in melting, preference always being in favor of a close vessel—as a crucible with a cover.

First, melt the antimony, keeping the molten metal covered with a flux of powdered borax and resin, (each four parts,) and one part potash, thoroughly mixed, to which add the lead. Melt the other two metals in separate vessels—the tin first. Then add the flux, and then the zinc. When melted, stir thoroughly with a stick of white wood. Now, pour the molten antimony and lead into the zinc and tin, stirring the whole thoroughly during the pouring out, keeping the mass covered with the flux to prevent oxidization by exposure to the atmosphere.

Combining metals positive and negative to iron in such proportions as to the liquids to be resisted, so that there shall be the least amount of energy exerted to perform the work, forms the principle of this invention. Different waters require different proportions of the metals.

The rendering of iron electro-negative (and hence preventing its affinity for oxygen) can only be done at some cost of force, but the cost of force required can be regulated, it is claimed, by Holden's mixture of metals so perfectly as to be almost nothing. To illustrate: When iron is subjected to the action of saline water Holden would use—zinc, 40 parts, by weight; tin, 50 parts; lead, 10 parts; antimony, 5 parts; but if the same water was above a boiling heat, he would use—zinc, 33 parts; tin, 50 parts; lead and antimony, each 1 part. In fresh neutral waters he would use—zinc, 50 parts; tin, 33 parts; lead, 10 parts, and antimony, 5 parts. In acidulated water he would use—zinc, 33 parts; tin, 50 parts; lead and antimony, each 1 part; or in proper proportions to resist the action of the liquid in which they may be placed.

Taylor's Compound.

Taylor patented the following compound for removing scale and preventing the formation of insoluble deposits: 5 pounds of chestnut-oak bark, ½ pint honey, 2 ounces washing soda, 1 quart extract sumac, 1 quart extract Irish moss, and 1 quart extract slippery-elm to 2 gallons water.

Heimann's Method.

Heimann's means for preventing the incrustation of steam boilers consists in adding to the feed water, when it is already in the boiler, roasted and ground coffee-beans in quantities depending upon the nature and quantity of solid substances dissolved in the feed water.

It is claimed that the effect of this addition is to coat the inside of the boiler plates with a fatty substance which prevents the adhesion of the incrustation, and that the chemical compounds or products of decomposition formed by roasting the coffee beans cause the solid substances, dissolved in the boiled water, to be precipitated in the shape of powder or mud.

Wishart's Process.

Wishart's process for removing the incrustations from a boiler of 20 horse-power is as follows: In order to have a full supply of water for the operation he puts into the boiler 3 full gauges; then introduces therein, for the purpose of cleansing the water, 3 pounds of chlorine water, and heats the whole to a temperature of 100° F., at which point it should remain for about one hour.

For the purpose of softening the incrustations, Wishart then introduces ½ pound of carbonate of magnesia with 12 pounds of spirits of sea salt, and the water is left to remain another hour at the same temperature. Then for the purpose of hastening the operation, 3 gallons of common vinegar or 2 gallons of concentrated vinegar are introduced.

The materials now having all been introduced into the boiler, the latter may be closed steam-tight—by properly securing the manhole plate and dome covers in place and closing the throttle valve. The safety valve lever may be set to allow the escape of steam at 80 pounds pressure.

The fire may now be gently started under the boiler and the steam be raised to 20 pounds pressure, at which point the patentee states it should remain for about 6 hours. The pressure may then be gradually raised to 40 pounds pressure, about at which point it should remain for 6 hours longer. Then increase the pressure to 80 pounds, at which point it is allowed to remain for a half hour. Instead of allowing the boiler to cool gradually, the advantages of which have been enlarged upon, the patentee of this process recommends that the water from the boiler now be blown off, and that the handhole and manhole plates and dome covers be removed and the boiler allowed to cool.

Cleaners or scrapers are then taken and all incrustations that have been loosened by the operation are drawn from the boiler, and when the boiler is cool enough to accept of water, the hose is applied with as much pressure as possible, for the purpose of removing the softened incrustations from the crown sheet, stay bolts and flues.

North's Process.

North's process is to treat the water, at its ordinary temperature, in proportion to the sulphate of lime, carbonic acid gas, carbonate of lime, and carbonate of magnesium found therein by analysis, with about equal quantities of carbonate of sodium and chloride of ammonium, before they are mixed, to change the sulphate of lime to carbonate of lime and absorb the carbonic acid gas, and then heating the water to change the carbonates into chlorides, which are soluble at any temperature of the water.

Sulphate of lime is soluble in cold water, but is almost insoluble in hot water. Therefore, as soon as the water is heated, the sulphate of lime is precipitated. Carbonate of lime is almost insoluble in pure cold water, but is held in solution by the free carbonic acid gas in the water. Heat drives off this gas, and the carbonate is precipitated. Carbonate of magnesium acts in the same manner as carbonate of lime. Carbonic acid gas in solution in an iron boiler unites with the iron, and forms carbonate of iron, which is insoluble.

When carbonate of sodium is added to water containing sulphate of lime in solution there is a double decomposition, and there is formed sulphate of sodium, which is soluble, and does no harm in the boiler. Carbonate of lime is also produced. The excess of lime and sodium in the water absorbs the free carbonic acid gas. When chloride of ammonium is added to water containing carbonate of lime there is a double decomposition, and there is formed chloride of lime, which is soluble, and carbonate of ammonium, which is volatile. Chloride of ammonium has a similar action on carbonate of magnesium.

The quantity and proportion of carbonate of sodium and chloride of ammonium depend upon the quantity and proportion of lime and magnesium in the water. It generally takes equal amounts of each, the water being analyzed to determine these amounts.

The carbonate of sodium and chloride of ammonium must not be mixed before adding to the water, as they would decompose each other, which they will not otherwise do, as the sulphuric acid, in connection with the lime, has more affinity for the sodium than for the lime or anything else in the water. It therefore separates from the lime, and drives the carbonic acid from the sodium, and unites with sodium to form sulphate of sodium. The lime and carbonic acid unite to form carbonate of lime. At the ordinary temperature of water the chloride of ammonium remains in solution. It requires heat to cause it to act with the carbonate of lime.

A proper proportion of the chemicals should be put into the water to be used each day.

The water may be heated before being put into the boiler to complete the chemical changes; but the heat in the boiler will accomplish the same result. The water need not then be subjected to filtration, the chlorides formed being soluble.

The carbonic acid gas being neutralized or absorbed, carbonate of iron will not be formed in the boiler. The chlorides of lime and magnesium and the sulphate of sodium being soluble at all temperatures of the water, and the carbonate of ammonium being volatile, they will not form scale or incrustation.

Bacon and Queen's Process.

Bacon and Queen's process for removing incrustation in steam boilers is as follows: Lime water, composed of 1 ounce pure unslaked lime and 11 ounces soft water, are well mixed together, and after standing 10 or 12 hours it is filtered and 16 ounces of it is added to 16 ounces of pure sweet oil. The lime water and sweet oil having been mixed together are used as follows: For example, if a 10 horse-power boiler running 10 hours per day and evaporating about 12 barrels of water is used, a quantity of this compound not exceeding 1 pint is injected in some suitable manner every other day until the desired effect is produced—that is, until any old incrustation that may exist in the boiler is softened to such an extent that it can easily be removed by washing out the boiler in the usual way.

Absolutely pure sweet oil must be used, as common sweet oil will not mix with the water in the boiler.

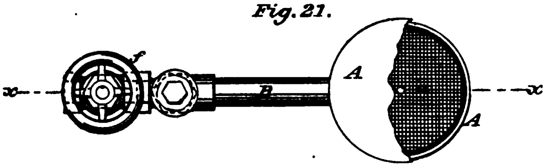
This compound is especially adopted to be used in small boilers where mechanical lime extractors cannot be employed. Oil alone will soften the deposit; but as oil does not mix well with water the patentees prefer to mix it with lime water, as has been described.

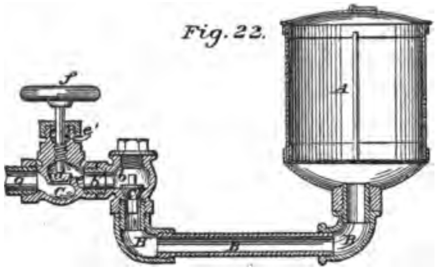
SECTION III.—APPARATUS FOR FEEDING FLUID INTO BOILERS TO PREVENT INCRUSTATION.

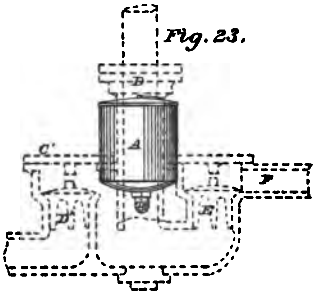
Linehan's Device for Feeding Fluid into Boilers to Prevent Incrustation.

The object of Linehan's invention, shown in Figs. 21 to 23, is to furnish a device for automatically feeding the fluid, for preventing

Fig. 21.







incrustation, into the boiler along with the feed water, when supplied by a pump or an injector.

It consists of a reservoir for holding the fluid, from the bottom whereof a siphon pipe leads to the pump barrel or injector at a point where the water is forced or drawn by suction into the boiler. The said siphon pipe is supplied with a stop cock and check valve, to regulate the amount supplied and to prevent back pressure when pumping.

Fig. 21 is a plan of Linehan's apparatus. Fig. 22 is a longitudinal vertical section of the same, taken on line *x x* of Fig. 21; and Fig. 23 shows it applied to a pump barrel. A represents the fluid reservoir, provided with a circular strainer, *a*. From the bottom of this reservoir a pipe, B, leads to a valve chamber, *b*, in which is seated a puppet check valve, *c*. This valve chamber is on a level with the bottom of reservoir A, and from it extends a tube, *b'*, with a valve chamber, C, connected with it, provided with a conical valve, *d*, seated in the diaphragm *e*. The stem of this valve projects out through a stuffing box, *e'*, and is provided with a hand wheel, *f*, for operating the valve *d*. From valve chamber C a tube, *g*, extends, for connecting the device with the pump barrel or injector, as the case may be.

The device is applied as follows: In Fig. 23 it is shown applied to a pump, C', (illustrated in dotted lines.) The tube *g* is connected with the pump barrel D anywhere between the suction valve D' and discharge valve E. The stop cock or valve *d* is lifted off its seat sufficiently far to allow the proper quantity of the fluid to pass from the reservoir A into the boiler. The fluid is put in reservoir A, and passes down through pipe B, through valve *c*, thence through the tube *b'*, valve chamber C, to tube *g*, and from this tube *g* it enters the pump barrel D. When the pump is drawing it lifts check valve *c* from its seat, which permits the fluid to flow through to the pump barrel; but on the return stroke it closes the check valve *c*, thus preventing back pressure in the feeding device, and the fluid that flows out on the suction stroke, mingling with the water, is forced through valve E, and thence, through discharge pipe F, into the boiler. Thus at every suction stroke of the pump a certain quantity (regulated by stop cock *d*) is permitted to flow into the pump barrel D, and on the return stroke it is forced into the boiler.

By this arrangement a small but sufficient quantity of the anti-incrustation fluid is regularly and automatically fed to the boiler, preventing waste and acting with better effect than when forced into the boiler in quantities.

The device is equally applicable to an injector, and when so used it is attached on the suction side.

Pindar and Clark's Apparatus for Feeding Scaling Compounds to Steam Boilers.

Pindar and Clark's apparatus shown in Fig. 24 is employed to inject chemical compounds into steam boilers for the purpose of preventing scaling and incrustation; and it consists in the use of a chambered cylinder and devices by means of which the water-feeding device acts as the forcing medium for injecting the compound into the boiler.

Fig. 24.

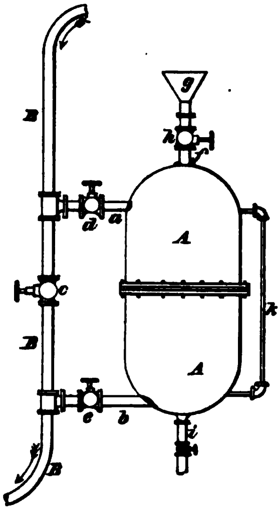


Fig. 24 represents an elevation of an apparatus embodying Pindar and Clark's invention.

B represents the usual boiler-feeding pipe, leading from the main water supply to the boiler, and through which the water is forced to the boiler by any of the well-known devices, and this invention calls for no change therein.

A represents a chambered cylinder, which may be formed from sheet metal in any approved manner, or by casting, as may be preferred, its size and desired capacity being determined according to circumstances. This cylinder A is connected with the feed pipe B at its top by means of inlet pipe *a* and near its base by means of outlet pipe *b*. Such pipe connections may be of sufficient strength to support the cylinder A in its position, as shown in the drawing, or it may be sustained by means of brackets attached to the boiler, or upon a suitable stand, as preferred. The main water-feed pipe B is provided with a cut-off valve, *c*, midway between the points where the pipes *a* and *b* (connected with chamber A) are joined to the feed pipe B. The two pipes *a* and *b* are also provided with valves *d* and *e*, as shown. At the top of the chambered cylinder A an inlet pipe, *f*, is attached, which at its apex supports a permanently attached funnel, *g*, a valve, *h*, in the pipe *f* furnishing a means of closing the entry to the cylinder A. At the base of the cylinder A an outlet pipe, *i*, is attached, by means of which the cylinder may be entirely emptied. A glass gauge, *k*, is attached to the chambered cylinder A for the purpose of indicating the quantity of fluids contained therein.

The operation of Pindar and Clark's device is as follows: The valves *d* and *e* being closed and the valve *c* in the feed pipe B being open, the supplying of water to the boiler goes forward in the ordinary manner. The chemical compound is now introduced into the chambered cylinder A by pouring it into the funnel *g*. The valve *h* then being opened, it at once passes into the chamber of cylinder A. When the proper quantity has been admitted, as indicated by the glass gauge *k*, the valve *h* is closed. The valve *c* in the feed pipe B is now closed, and the valve *e* in the pipe *b*, connecting the base of the cylinder A to the feed pipe B, is opened. The valve *d* in the pipe *a* is then opened, when the water from the feed pipe B is at once forced into the chamber of cylinder A, and thoroughly commingles with the chemical compound therein contained, driving it out through the outlet pipe *b* into the main pipe B, and thence into the boiler. The action is continued until the entire quantity of compound placed in the cylinder has been ejected. The normal position of pipes, valves, &c., as first described, is then resumed.

CHAPTER V.

MECHANICAL BOILER-CLEANERS.

Hayes, Jeffery and Schlack's Device; The Hotchkiss Boiler-Cleaner; Korte's Apparatus; Jones' Apparatus; Doen and Miller's Method; Youngblood and Holmes' Collector; Kane's Sediment Collector; Hanna's Collector and Spraying Device; Fisk's Attachment; Ascroft's Electrical Alarm and Boiler Cleaner.

Hayes, Jeffery and Schlack's Device for Removing Sediment from Steam Boilers.

The crown or roof of the furnace in tubular boilers, by reason of its exposure to intense heat and its form, offers favorable conditions for the rapid formation of incrustations.

The difficulty of removing the scale from the crown is so great, in consequence of the numerous bars and braces supporting the sheet and limiting the room for the introduction and manipulation of the tools necessary for cutting away the deposits, that in many cases the attempt is not made, the sediment being allowed to accumulate until the spaces under and between the crown bars become obstructed to such an extent that the circulation of water over the furnace and the generation of steam are seriously impeded. It then becomes necessary to open the boiler, remove the crown bars and braces, and cut away the scale with suitable tools—an operation at once laborious and expensive. It is to this part of a boiler, and for the purpose of removing sediment there deposited, that the device shown in Figs. 25 to 31 is claimed to apply with special advantage. The primary object of the invention is to remove the sediment deposited on the upper surface of the crown sheet of a boiler to which the device may be applied without disturbing or removing any part of the boiler, the machinery attached, or the structure investing it, which the inventors claim they can accomplish by the use of water under suitable pressure.

A further object of the invention is the partial purification of the water in the boiler by ejecting from time to time a portion of the impure water through the apparatus, which then serves the purpose of a surface cock.

Fig. 25.

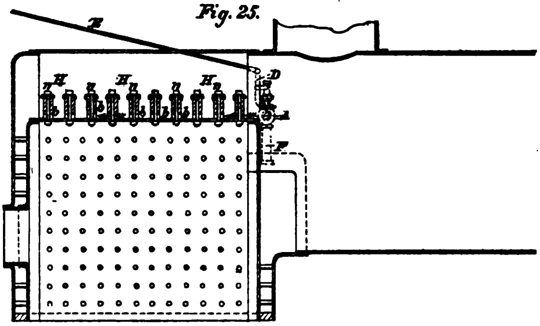


Fig. 26.

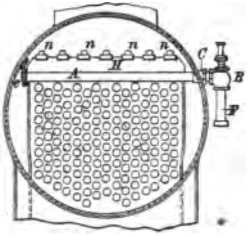


Fig. 27.

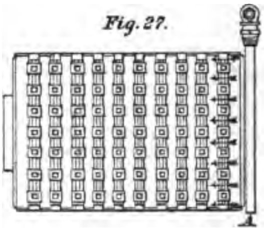


Fig. 28.

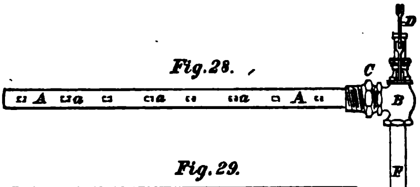


Fig. 29.

Fig. 30.

Fig. 31.

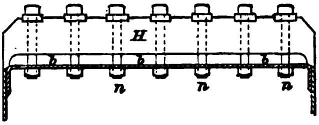


Fig. 25 represents a longitudinal section in elevation, through a boiler and furnace embodying Hayes, Jeffery and Schlack's invention. Fig. 26 is a transverse section of a boiler, showing a side elevation of the washing apparatus in position. Fig. 27 is a plan view ; Figs. 28 and 29 enlarged views of the device detached; Fig. 30 a longitudinal section of the wash pipe; Fig. 31 a section through the crown sheet of a furnace and between the crown bars, showing spaces between the crown bars and sheet, through which spaces jets of water are forced and distributed in the operation of the device.

The drawings show a locomotive boiler and furnace, and A represents a pipe located within the boiler, in front of and extending across the furnace, which may be secured in position in any suitable manner. The inner end of the pipe is closed, and the side toward the furnace is perforated at intervals, and the apertures *a* are slightly above the crown, and through them water can be forced over the crown, through the spaces *b*, between the crown-bar bolts *n*, and under the bars H. B represents a valve, which, when seated, prevents the escape of steam and water from the boiler, and when open affords a passage through the pipes connected therewith. C represents a metal sleeve passing through and securely fastened to the outside sheet of the boiler, affording suitable attachment for the pipe A and valve B. The inner end of the pipe is, as shown, held by a support, *c*. D represents a lever attached to the valve B. E is a rod connected to the lever D, by which the valve may be operated. F represents a pipe secured at one end to the valve B, and extending from the valve a sufficient distance to give room for the convenient attachment, at its opposite end, of a hose for supplying water to the pipe A.

The operation of the device in its primary function is as follows : Connection having been made at F with a water supply under suitable pressure, the valve B is to be opened, thus forming a continuous passage through the pipes F and A, and the water which escapes through the apertures *a* in the pipe A will be forced over the crown in strong jets, and will impinge on the surface of the sheet, and by its action it is claimed will dislodge and remove any deposits of sediment which may have formed there. At the time of applying the water it will be advisable to open the hand holes in the leg of the boiler, to allow the sediment to pass off with the water.

This operation should be performed frequently, as often as the boilers are allowed to cool, and before cooling, or at such other times as circumstances may require.

The device can be used as a surface cock by raising the valve B by means of the rod E and connecting lever D, which will permit the escape of the surface water charged with impurities, which, under the pressure of the steam in the boiler, will be forced through the apertures *a* into the pipe A, through the valve B and pipe F into the atmosphere, the quantity permitted to escape being regulated by the movement of the valve, as may be desired. Of course this operation is not performed when the pipe F is connected with the water supply.

The valve may be so arranged that the force of the water flowing under pressure through the tube F will open it.

The inventors of the above device, Messrs. Hayes, Jeffery and Schlack, have also invented an apparatus for purifying feed water for locomotive boilers by filtering it, and the latter appliance is mentioned under No. 226068 in the list of American patents, which is appended at the close of the present chapter.

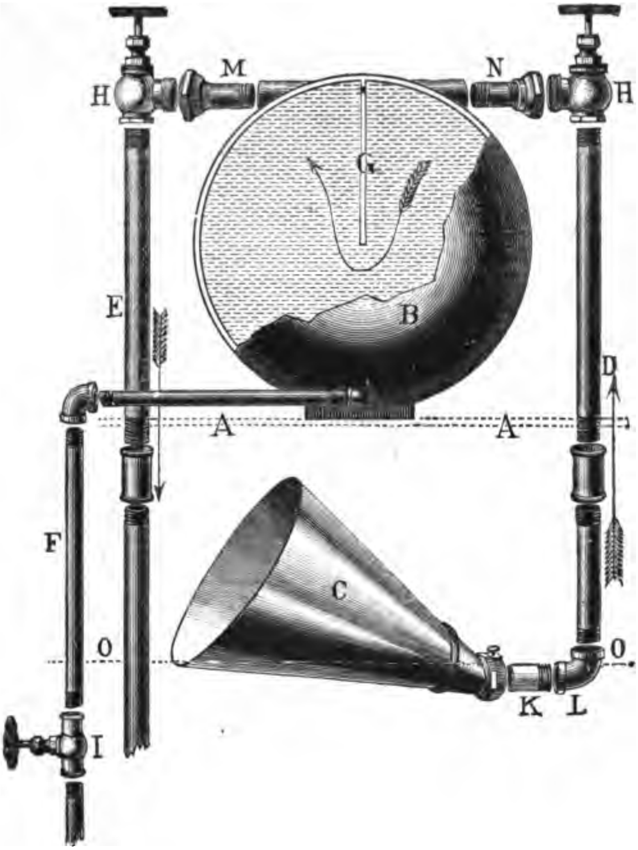
The Hotchkiss Mechanical Boiler-Cleaner.

The Hotchkiss mechanical boiler-cleaner, shown in Figs. 32 to 40, is automatic in its action, and it is the simplest and most effective device for keeping boilers free from scale that has yet come under the author's observation.

The separate parts of the Hotchkiss boiler-cleaner are shown in Fig. 32, the parts being represented arranged in their relative positions as applied to a steam boiler.

In Fig. 32 the double dotted line A A represents the top of the boiler shell, upon which the reservoir B rests, and which is connected with the funnel C by the up-flow pipe D, and to a lower part of the water in the boiler by the return pipe E ; in this manner is completed the circulation which flows in the direction shown by the arrows. The funnel C is set within the boiler on the low-water line, as indicated by the dotted line O. The diaphragm G is placed in the reservoir to divert the flow of water therein, and in the top of the diaphragm there is left an air hole, indicated by a black spot, and this hole should not be plugged. F is the blow-off pipe for removing the deposits from the reservoir. H H are two valves used to shut off the reservoir B from the boiler in case of leakage. Angle valves, as shown, are generally used to simplify the connections. I is a valve on blow-off pipe F. K is a socket nipple to which the funnel C is secured by

Fig. 32.



passing over a key, and is then held in place by the small thumb screw shown on the collar of the funnel. M and N are nipples, each with a half union in order to connect with valves H H.

The pipes and fittings are all 1½ inch, except the blow-off pipe F, for which 1 inch pipe and fittings are used.

The reservoir is a cast-iron spherical vessel with capacity of 18 gallons, it is $\frac{9}{16}$ inches thick and weighs about 215 lbs. It occupies when in position with pipes attached a space 28 to 30 inches long, 24 inches wide and 26 inches high. Being a solid casting without joints and with its spherical shape it is capable of standing a great pressure. Each one is tested with steam to 150 lbs. per square inch before sending out.

The funnel is made of best charcoal iron, the mouth or opening is 12x15 inches; it will fit into an ordinary manhole, but should the manhole be small the funnel may be bent so as to get it in, and afterward restored to its original shape.

The manner in which the apparatus acts in removing sediment from and preventing scale formation in steam boilers is as follows:

As soon as the water in a steam boiler becomes heated, currents are formed by the hotter water flowing upward and away from the source of the greatest heat, while the colder water flows to the source of heat and in its turn becomes heated. In all boilers where fire is applied at one end, the currents established will be upward and from the fire on the surface and downward and toward the fire in the lower part of the boiler. In a boiler with the Hotchkiss cleaner attached, the funnel is set near the surface but partly submerged, and in such position that its opening will intercept the currents of hot water flowing toward it. By the action of gravity in water of varying temperatures, aided by the pressure on the surface, the hot surface water that enters the funnel will flow into the reservoir through the up-flow pipe, displacing constantly an equal quantity of the cooler water therein, which, flowing back to the boiler by the return pipe, reaches lower and cooler strata of water than that entering the funnel; thus a steady and constant circulation of water through the apparatus is maintained so long as firing is kept up. This circulation is continuous and automatic, and by its certain and natural action, all the water in the boiler passes successfully through the reservoir, where, being free from the agitating currents in the boiler, favorable conditions are insured for the precipitation and deposit of sediments.

The sediments, once deposited in the reservoir, are removed through the blow-off pipe as often as necessary.

The office of the Hotchkiss mechanical boiler-cleaner is therefore simply to provide a place for the accumulation of sediments outside of the boiler itself, and removed from heat and its agitating effects, from whence they can be readily removed as fast as they accumulate, instead of shutting down the boiler to clean them out by hand, or by blowing down the boiler in the ordinary way, losing a large amount of water already heated to the steaming point, which, if replaced by colder water, is wasteful of fuel as well as of water.

It is not claimed for this apparatus that it will remove incrustations from boilers when the scale is already formed, but it is guaranteed that it will prevent the formation of new scale, by removing the floating deposits and mineral salts which become scale, if not removed from the water before they have had time to adhere to the heating surfaces.

By preventing the formation of new scale, the old, by expansion and contraction of the heating surfaces, becomes detached and may readily be removed.

Fig. 33.

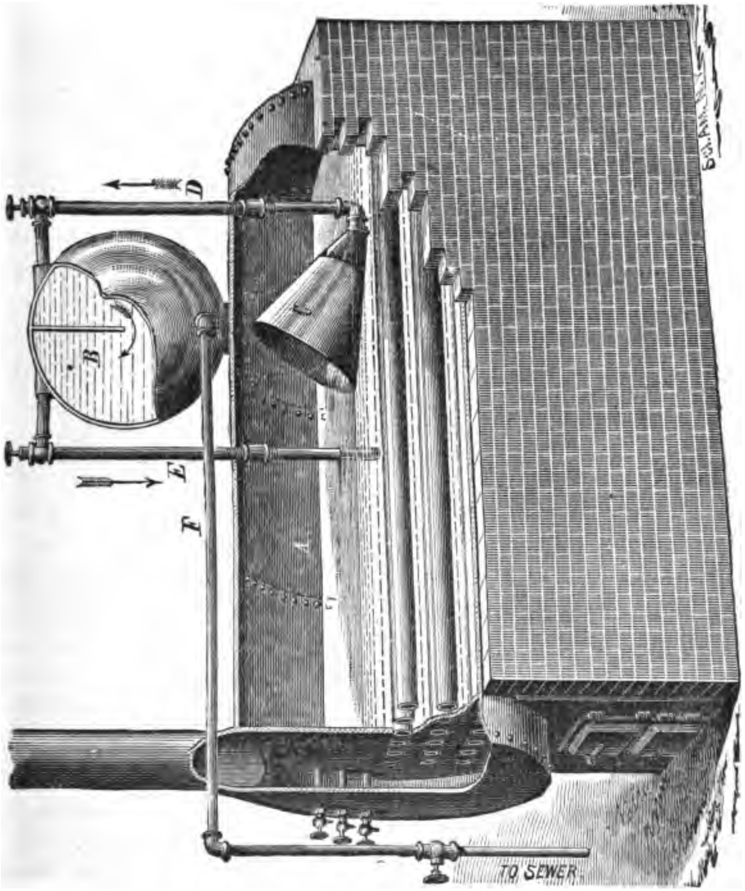


Fig. 33 shows the apparatus as commonly attached to a tubular boiler, and Figs. 34 to 36 show different situations in which the cleaner may be applied when for any reason it may not be desirable to place the reservoir on the top of the boiler in the usual way.

Fig34

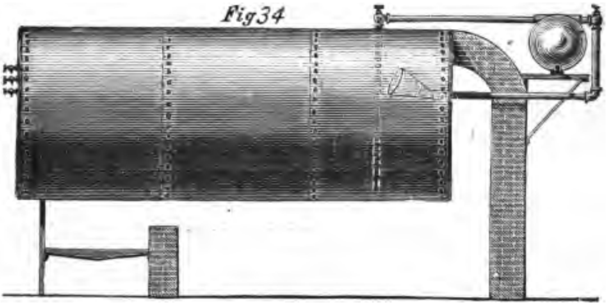


Fig35

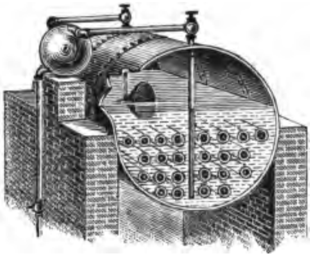


Fig36

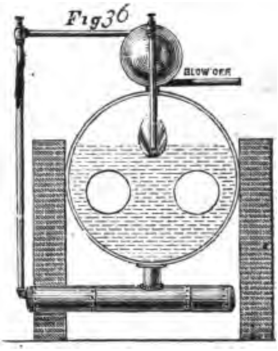


Fig. 34 shows the cleaner placed back of the boiler, when, for instance, a low ceiling would not allow it to be placed on top. Fig. 35 shows the reservoir placed on side wall, if for any cause, such as steam drum or manhole being in the way, it could not be applied in the ordinary manner. Fig. 36 shows connection of the return pipe to a mud drum, when if for any reason such connection is desirable.

The Hotchkiss apparatus is of peculiar value to tubular boilers, which from their construction are difficult of access for properly cleaning by hand, and therefore in great need of some device to remove the impurities in the water. For this reason, perhaps, more of them are in use on this class of boilers than any other.

In the earlier types of the horizontal tubular boiler, it was the practice to insert many small tubes as close as possible, and in order to increase the number they were placed in the style known as "staggered." This objectionable practice is fast dying out, since it has been demonstrated that space for circulation of the water, and facilities for inspection and cleaning, are of equal importance with heating surface.

Fig. 37.

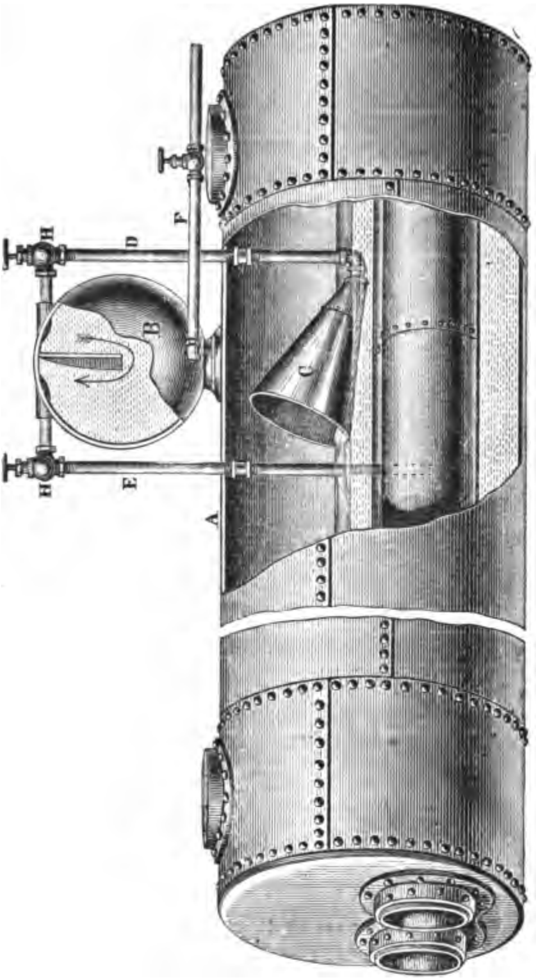


Fig. 37 shows the Hotchkiss mechanical boiler-cleaner applied to a two-flue boiler; the majority of the boilers used on the western rivers are of this type, and the Hotchkiss device has proved efficacious in removing the mud and sediment from such boilers.

A large number of the boilers used in rolling mills, saw mills, blast furnaces, &c., are two-flue and sometimes plain cylinder boilers; the cleaner is of especial benefit in such establishments, as it materially reduces the item of expensive loss of time in stopping works or furnaces to have repairs made.

Fig. 38.

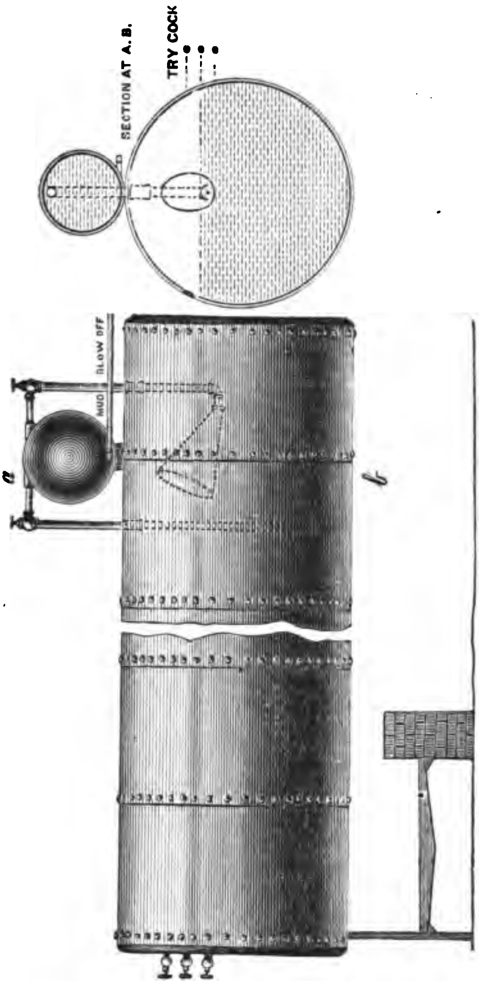


Fig. 38 represents the apparatus attached to a plain cylinder boiler, and it keeps such boilers clean, thus obviating the necessity of frequent cleaning by hand.

Cylinder boilers are an old type, now but little used. In most cases where their use is continued it is due to their superior accessibility for cleaning, thereby permitting the use of water which in boilers of more complicated construction could not be used without serious risk of damage to fire sheets, &c. The employment of the Hotchkiss cleaner will allow of a type of boiler being used with bad water which will give much better results from the fuel consumed; a feature in which the cylinder boiler is defective.

Fig. 39.

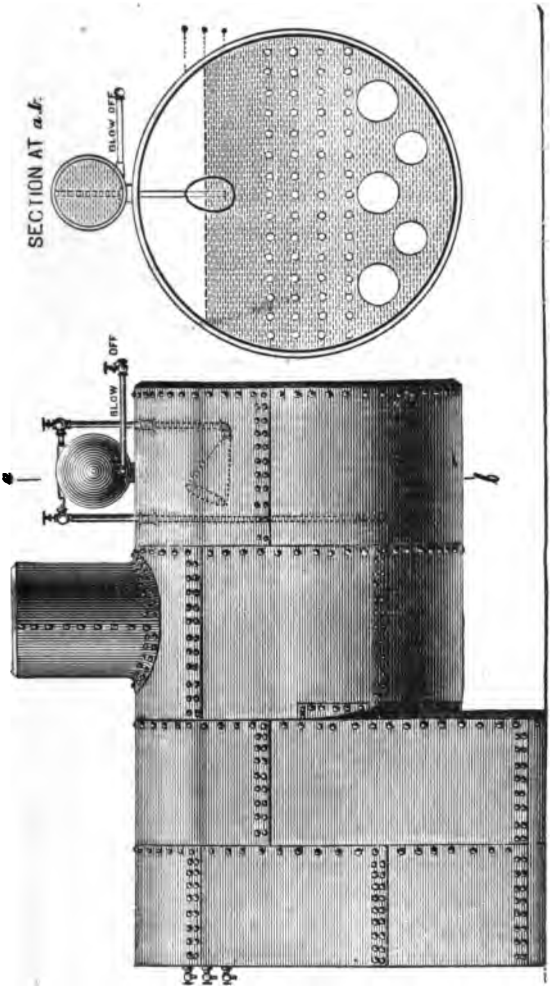
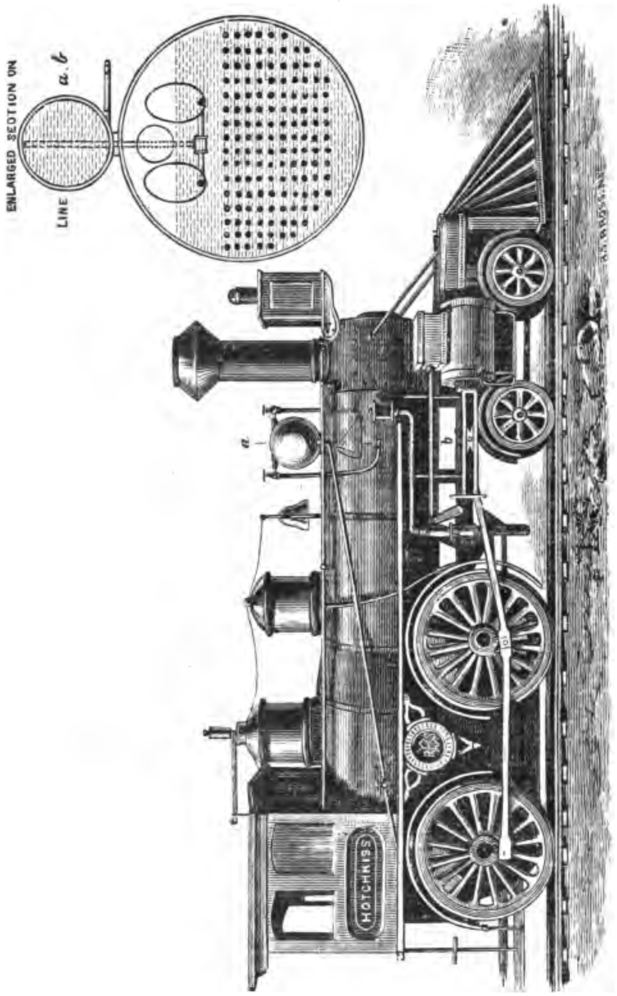


Fig. 39 shows this mechanical boiler-cleaner as applied to an ordinary return-flue marine boiler.

One of the advantages claimed for this cleaner in its application to marine boilers using salt water is, that it prevents the saturation of the boiler water with salt, as the reservoir will catch and retain the salt, thus saving the large waste of fuel which occurs in blowing off to prevent saturation.

A marine boiler without surface condenser, but fitted with the

Fig. 40.



Hotchkiss boiler-cleaner, it is claimed, can entirely dispense with fresh water and use sea water with perfect security.

Fig. 40 shows the Hotchkiss device attached to a locomotive, but the manner of applying it is, of course, not arbitrary as represented, for if preferred the up-flow pipe can enter the smoke arch, making connection with either one or two funnels through the front head of the boiler.

The return pipe may enter the boiler on the side near the check valve, as shown in Fig. 40, or may pass though the top of the shell into the boiler, as in ordinary cases. In Fig. 40 the cleaner is represented as having two funnels, one on each side of the dry pipe and connected to one up-flow pipe; this arrangement is preferable where the dry pipe divides the water surface longitudinally, otherwise a single funnel is generally sufficient.

The blow-off pipe may be carried in any direction, but, as shown by Fig. 40, it is preferable to have the valve within reach of the engineer. This cleaner is of special benefit to locomotives, as from the peculiar construction of the boiler thorough cleaning by hand is difficult if not impossible, and as it is claimed that it obviates foaming in boilers, its application should save a deal of trouble and a large item of expense in the renewal of burnt tubes, &c.

The railroad companies and others in the western States, using alkaline waters for boiler purposes, could obtain much relief by employing the Hotchkiss device. By its use the waste of the common surface blow-off can be obviated and much better results secured in every respect.

The Hotchkiss mechanical boiler-cleaner can be applied to upright boilers with good results.

As upright boilers are usually constructed, access to their interior is confined to facilities offered by hand holes, and even in the largest types the space surrounding the tubes and fire surfaces are only imperfectly to be reached; for this reason, it is difficult to clean them effectually, so that they are a source of constant trouble and expense for burnt tubes and fire surfaces. The more difficult a boiler is for access to clean, the greater need there is for some device which will purify the water.

Owing to the impossibility of gaining admittance to the interior of upright boilers the manufacturer, Jas. F. Hotchkiss, No. 86 John Street, New York City, N. Y., makes and supplies special fittings for attaching the cleaner to this class of boilers at the same price as charged for regular cleaners.

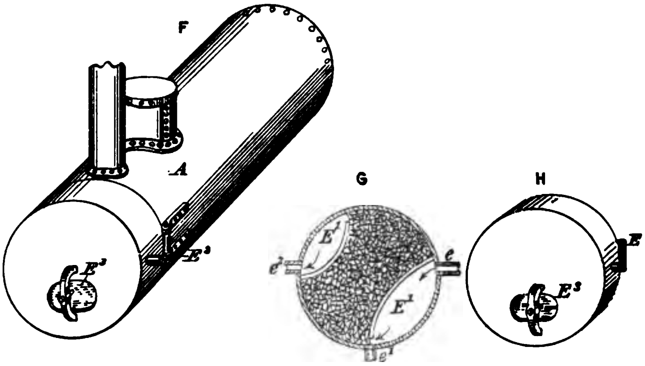
Upright boilers vary so much in the arrangement of their internal parts that no general rule can be laid down for applying the cleaner to them; but if a sketch of the boiler, or if of a special type, the name of such be furnished, special directions will be sent by the inventor in each case.

Korte's Feed-Water Heater and Sediment Collector.

The object of Korte's invention, shown in Figs. 41 to 43, is to construct a feed-water heater in sizes suitable for insertion within the smoke box at the end of the boiler adjacent to the smoke stack or uptake, so as to be heated with the waste heat of the products of combustion as they escape from the boiler flues or tubes and are about to pass to the chimney flue.

A further object which the inventor has in view in the construction of this feed-water heater is that it shall collect the impurities of the feed water and swing out upon a hinge, the same as the ordinary door located at the point described, so as to give ready access to the boiler flues or tubes, in case it is desired to get at them for cleaning or repairs.

Fig. 41.



In the drawings, Fig. 41 shows three separate views: at F a perspective view of a boiler embodying Korte's invention; at G a separate view of the feed-water heater; and at H there is shown a sectional

Fig. 42.

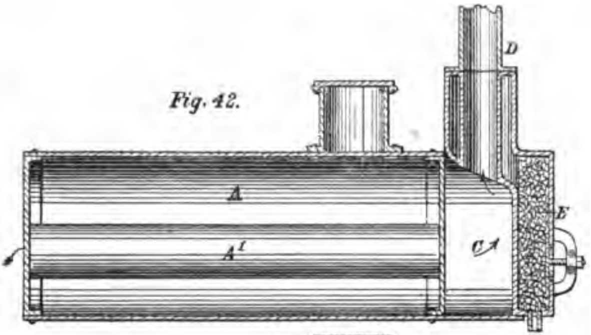
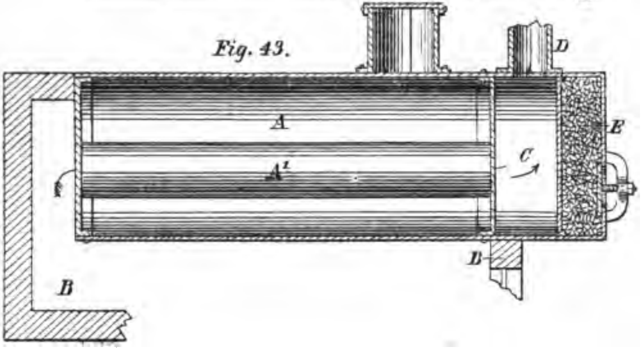


Fig. 43.



view of F. Fig. 42 is a sectional view, showing a modification of the invention. Fig. 43 is a longitudinal section.

A is an ordinary horizontal boiler. B is the furnace. A′ the boiler flues or tubes. C is the smoke box. D the chimney or uptake.

E represents the feed-water heater, which is of such size and dimensions as to fit within the end of the smoke box, although, instead of fitting within the end it may be adapted so as to fit against the end. It is provided with two or more interior partitions, E′. Two are represented in the drawings, and they divide the interior spaces into three chambers.

e is the inlet for the feed water ; *e*′ the mud valve or blow off, and e^2 the exit for the feed water. The middle space is represented as filled with hay, straw, excelsior, or their equivalent filtering material.

The operation of the device is as follows : Feed water entering at *e* is heated by the waste heat of the products of combustion as they escape from the boiler flues and before passing to the chimney. Being heated, the water deposits the main portion of its sediment in the lower chamber adjacent to the blow-off e'. Its remaining impurities and crystallizable salts, it is claimed, are extracted in passing through the filtering chamber and the space beyond it, and the water discharged in a purified and heated condition from the exit e^2, whence it is pumped into the boiler.

E^2 is a hinge by which the heater is suspended in its place, thus making the heater to serve the purpose of a door for gaining ready access to the boiler flues or tubes. The heater may be provided with manholes E^3, opposite any or all of its interior chambers, to facilitate the cleansing of the interior or renewal of the filtering material.

This heater may, if preferred, be extended upward through the base of the smoke stack and include the base of the stack within it, as illustrated in the modification shown in Fig. 42, so as to form a part of the stack, the heater being suitably joined to the stack at the top, the smoke passing through the upper part of the heater.

The inlet or exit pipes for the water may be united with the heater by flexible pipes or couplings, so as to admit of opening the door without disconnecting the pipes; or they may be rigidly connected, in which case they would have to be unjointed from the end of the smoke box before opening the heater.

Jones' Apparatus for Removing Scale and Sediment from Steam Boilers.

Jones' apparatus for removing scale and sediment from steam boilers is shown in Figs. 44 to 49.

In the use of mechanical scrapers it is necessary that the rod or stem to which the scraper is attached should pass out through the head of the boiler, so as to operate it while the boiler is in use. In practice the rod sometimes breaks, and in one case which we recall where this occurred the rod and the hot water were blown out through the stuffing box, to the peril of the life of the engineer, and the steam had to be let down in order to close the stuffing box. In order to obviate these difficulties the scraper rod has in the present invention been provided with a socket and ball valve, so that in case the rod should at any time be withdrawn the ball will fall into the socket, and thus close the orifice.

Fig. 44.

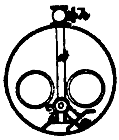


Fig. 45.

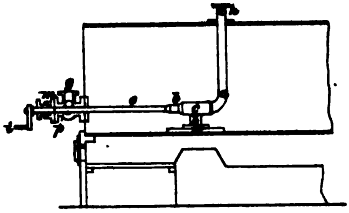


Fig. 48.

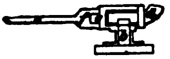


Fig. 46.

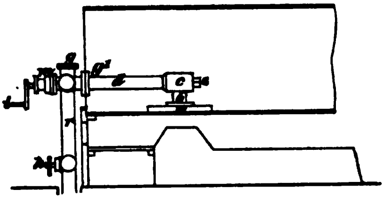


Fig. 49.

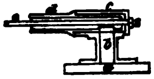


Fig. 47.

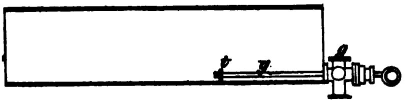


Fig. 44 indicates a cross-sectional view of a steam boiler with Jones' oscillating scraping-deflector, and Fig. 45 is a longitudinal section of same, showing a front connection for operating the deflector, and a socket and ball valve so arranged as to force the mud and scale up and out of the top of the boiler. Fig. 46 is a longitudinal sectional view of a boiler with Jones' oscillating scraping-deflector, with socket and ball valve so arranged as to blow off the mud and scale through the front head of the boiler. Fig. 47 is a view of same with one scraper and socket and ball valve. Fig. 48 is a view showing the internal construction of the sleeve and scraper shown in Fig. 45. Fig. 49 is a like view of the same parts as shown in Fig. 46.

In the application of this apparatus to a double-flue boiler, such as is used upon Ohio river steamboats, the inventor places an oscillating deflector (having the sides bent down) over the fire-bridge sheets, such as shown in Figs. 44 and 45. The deflector *a* is about six inches wide and two feet long. The scraping sides extend downward about one and one-half inch on each side, the ends being open. This deflector is riveted to a hollow arm, *b*, which is a part of the sleeve *c*. The sleeve *c* is supported by and oscillates around the pipe *d*, which passes into the sleeve.

The valve rod *e* is attached to the sleeve *c* by means of a socket, *f*. The valve rod passes out of the boiler head through the case of the ball valve *g*. When the engineer wishes to clean the scale from the fire-bridge plate the valve *h* is opened and the crank *i* is worked back and forward, which oscillates the sleeve *c* and causes the scrapers *a* to scrape the scale and loosen it from the boiler, and the scale and dirt will pass through an opening of the deflector into the arm *b* and into *d* and out of valve *h*. Should the valve rod *e* break and be forced out, the ball *o* will be forced into the socket *p* and close the opening, so that no water can escape.

It will be observed that the ball *o* lies loosely upon the valve rod, so that it closes the opening automatically the instant the rod is removed from any cause.

In the application of this apparatus to boilers where it will not be convenient to blow up through the top of the boilers, as shown in Figs. 44 and 45, it may be put on in the manner shown in Fig. 46, in which the pipe *d* is attached to the boiler head by the flange *q'*, and a communication is made through the head with discharge pipe *r* and ball valve *g*. The valve rod *e* passes through *g* and *d*, and is fastened to the closed end of the sleeve *c* by the nut *s*. When it is desired to blow off, the valve *h* is opened and the crank *i* is worked backward and forward, which causes the sleeve *c* to oscillate and the deflector scrapers to clean off the scale, when scale, dirt, and mud will be blown out through *b d r* and valve *h*. All of these ball valves are provided with stuffing boxes, as shown at *m*, so as to keep the valve rods steam and water tight.

In the ordinary practice of double-flue boilers the arrangements shown in Figs. 44, 45, and 46, it is claimed by the inventor, will be amply sufficient to keep the boilers clean.

In blast furnace or like boilers, where a considerable length of the bottom of the boiler is to be scraped, the inventor uses a stout rod, *y*, (Fig. 47,) adapted to be pushed and pulled, armed with a scraper, *t*, said rod passing through the stuffing box and case of the ball valve, substantially as shown.

The rod *y* may be of any suitable length and diameter to do the work.

Doen and Miller's Method for Preventing Incrustations in Steam Boilers.

The object of Doen and Miller's invention, shown in Figs. 50 and 51, is to prevent the formation of incrustations and sediment inside of boilers on the bottom part of their shells; and it consists of a screen formed of wire cloth with open meshes, or of a piece of sheet metal perforated with holes, and stretched horizontally the entire length and width of the boiler under the flues and above the bottom of the boiler, where incrustations and sediment are the most troublesome and dangerous. This screen may be provided with a trap door or other suitable opening near the broom hole in the boiler, through which the scales can be taken out when desirable.

Fig. 50.

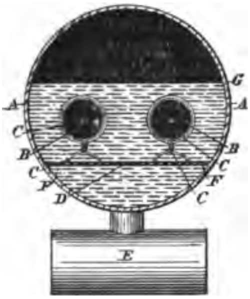


Fig. 51.

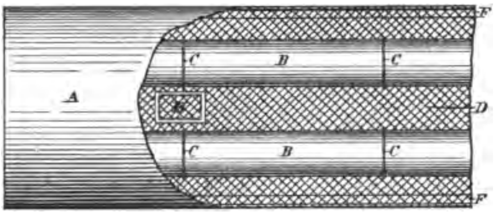


Fig. 50 is an end view of a transverse section of the shell of a boiler having Doen and Miller's screen. Fig. 51 is a view of the screen exposed by tearing away a part of the upper portion of the shell of the boiler.

A is the shell of the boiler; B, the flues; C, the wires around the flues, and twisted together underneath, and the strands then separated, stretched in opposite directions in a line passing across the boiler, and then attached to the screen. The screen hangs from the flues by these wires. The wire screen is stretched upon the frame F, which bears upon and against the sides of the boiler. E is the mud drum; D, the screen; G, the water line; H, the trap door.

During the time that the engine is in motion the inventors claim that the scales and incrustations form wholly about the flues, and in the ordinary boiler as soon as the engine stops they settle to the bottom and remain there, forming incrustations.

By means of this improvement the screen underneath the flues catches, it is claimed, this falling sediment, and prevents it from reaching the bottom of the boiler, which, in consequence, is kept clean and free from incrustation and scales.

Youngblood and Holmes' Boiler-Scale Collector.

In many muddy rivers, such as as the Mississippi, &c., where the river water is used in steamboat boilers, a great deal of sediment or scale quickly adheres to the crown sheet of the boiler and causes by

Fig. 52.

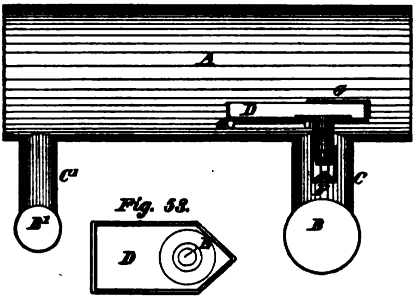
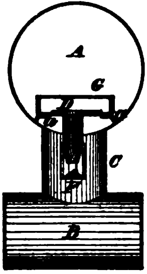


Fig. 53.

Fig. 54.



its presence an unequal heating and consequent distortion, bulging, and frequent fracture of the crown sheet.

Youngblood and Holmes' invention, shown in Figs. 52 to 54, is designed to protect the crown-sheet of the boiler by preventing this deposit or scale.

Fig. 52 is a sectional side-elevation of a boiler, showing the scale collector in position. Fig. 53 is a plan of the collector. Fig. 54 is an end elevation of the boiler, partly in section, showing the scale collector in position.

A represents the boiler, provided with mud drums B B′, attached to the boiler by their legs C C′. D is the scale collector, which may be a metal pan from three to six feet long, or thereabouts, from twelve to eighteen inches wide, and from two to four inches deep, and provided with feet *a a*, to hold it a few inches above the crown sheet of the boiler. It is also provided with discharge pipe E, which passes down through the crown sheet of the boiler into the leg C of the mud drum B, whereby the mud and scale deposited in this collector are conducted into the mud drum B. On the end of this discharge pipe E is a cap, F, the object of which is to prevent the mud and scale from returning to the scale collector.

Ordinarily the scale collector D is uncovered; but sometimes, when used in a boiler where there is a violent circulation of water, it may be partially protected by a cover, G, which serves to prevent undue agitation of the water in the scale collector D, thereby facilitating the deposit of the mud in it.

When the scale collector D is placed in the position shown in the drawings and the boiler is in operation, a violent circulation of water is caused on the crown sheet beneath the collector, so that all deposit and scale upon the crown sheet, it is claimed, is thereby prevented. The point of least circulation in the boiler, it is claimed, is immediately above and within the scale collector D. Consequently the mud tends to deposit within this collector, and to gravitate thence into the mud drum B of the boiler.

Kane's Sediment Collector for Steam Boilers.

As the greatest heat is applied to that part of the boiler just above and in front of the bridge wall, the evaporation and commotion are greater at this point.

The object of Kane's invention, shown in Figs. 55 to 58, is to intercept the impurities while circulating in the water, before they have settled upon the boiler-shell, and to collect them in a receptacle so that they can be readily removed.

Fig. 57.

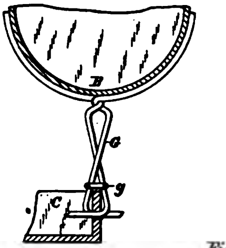


Fig. 55.

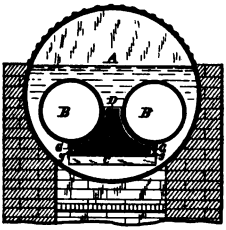


Fig. 56.

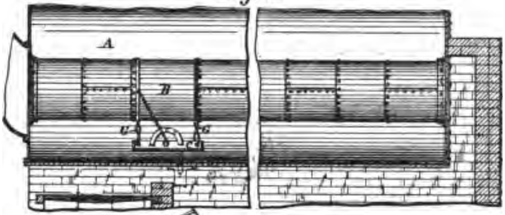


Fig. 58.

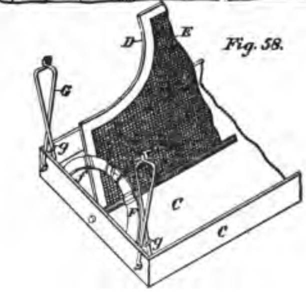


Fig. 55 is a vertical transverse section taken through the grate bars of a furnace and boiler, the latter fitted with Kane's device. Fig. 56 is a central vertical longitudinal section of the same. Fig. 57 is an enlarged detail view of the hangers by which the scale receptacle is suspended, and Fig. 58 is an enlarged perspective view (about one-half being broken away) of the receptacle and screen. In this view the screen is shown, as it is in Fig. 56, inclined toward the front of the boiler, and the inventor states that he has found that in this position it gives the best results.

A represents a boiler of ordinary construction, having two flues, B B.

C is rectangular sheet-metal vessel, pivoted within it is a metal frame, D, within which is stretched a screen, E, of wire cloth or perforated metal. The screen frame is held in either a vertical or inclined position by brackets F, which are secured to the ends of receptacle C, and have notches *f* opposite each other to receive the edges of the frame D, which is held between the brackets by spring pressure.

The device represented clearly in Fig. 58 is suspended from the flues (see Fig. 55) by hangers G. The hangers are made of wire loosely looped around the flues, so as to permit them to be moved along to the desired position. The lower ends of the hangers are hooked to pass each other through perforations or eyes in the corners of receptacle C. The shanks of these hooked tongs are crossed, and are provided with slides *g*, which hold them together securely locked through the eyes of the receptacle, and which, when moved up to the point of crossing, permit the hooked ends to be sprung out of their eyes and the receptacle to be detached for removal with its contents. The upper portion of the screen frame is curved upon each side to hug the flues and permit the reduced upper end to pass up about half way between the flues B B. This brings the screen fairly within the backward current and in a position to intercept the loose scale and sediment contained in the water, when it will drop into the receptacle. The wire gauze which the inventor has found best is about No. 5. This is open enough not to interfere with the circulation, while fine enough to intercept the scale and sediment, which usually settle on the shell of the boiler above the bridge wall, causing the boiler to burn or blister.

In Fig. 56 there is shown, in dotted line, a pipe leading down from the bottom of the receptacle. This is for use on steamboat boilers in which the mud-drum is located just back of the bridge wall, and by this arrangement the scales may be discharged from the receptacle by opening the mud valve; the receptacle being so suspended that no portion of it shall touch the shell of the boiler. Thus the circulation is not interrupted, and there is no object upon the inside shell of the boiler around which scale will settle.

The suspended receptacle will produce good results without the screen deflector, but it will not collect so much of the loose scale and sediment as it does with the screen.

Hanna's Sediment Collector and Spraying Device for Boilers.

Hanna's sediment collector and spraying device is shown in Figs. 59 to 61. The spraying nozzle is made with a lower conical surface, as well as with an upper conical surface to pass the water into the nozzle in a thin film or sheet, which is thus enabled to be thoroughly sprayed through perforations, graduated in size, made in the lower surface of the nozzle.

Fig. 59

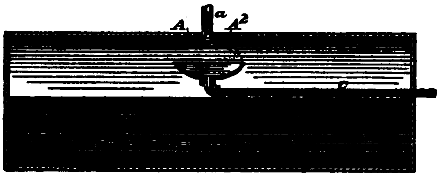


Fig. 60.

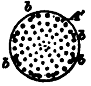


Fig. 61.

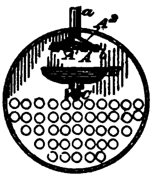


Fig. 59 is a sectional elevation of Hanna's feed-water device for boilers. Fig. 60 is an inverted view of the spraying device proper; and Fig. 61 is also a sectional view of the device, taken at right angles to Fig. 59.

In carrying out his invention Mr. Hanna employs a spraying nozzle, A, affixed to the feed-water pipe *a* of the boiler, and arranged within the steam chamber of the boiler. The nozzle A is provided with a lower conical surface, A′, as well as an upper conical surface, A^2, its lower surface having a series of graduated perforations increasing in size toward the outer edge of the nozzle. This construction, while by having the reduced sized apertures at the inner circumference of the nozzle, retarding the spraying or feeding of the water at the point least desired, or into the sediment collector, presently described, passes the water in a thin film or sheet of water toward the outer edge of the nozzle, whence it is fed through the increasing sized perforations in the boiler, unaccompanied, it is claimed, with an appreciable quantity of sediment. The nozzle A has its lower surface or plate bolted to and removable from the upper plate, as at *b*, to permit the ready cleansing of the nozzle or removal for other purpose of the lower plate. Thus bolting the parts together strengthens the nozzle, rendering it more durable and efficient.

B is the sediment collector, preferably of a saucer or funnel shape, arranged directly under and a short distance from the nozzle A, and attached to and discharging into a pipe, C, leading through one end of the boiler, and provided outside thereof with a blow-off cock to remove sediment therefrom.

Fisk's Anti-Incrustation Attachment for Boilers.

Fisk's device for preventing the incrustation of boilers is shown in Figs. 62 and 63 and it consists in the employment of a series of water pans of peculiar construction, placed loosely in the boiler on the flues, resting one above another, and receiving the feed water through a suitable pipe.

Fig. 62.

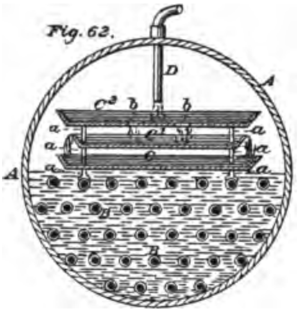


Fig. 63

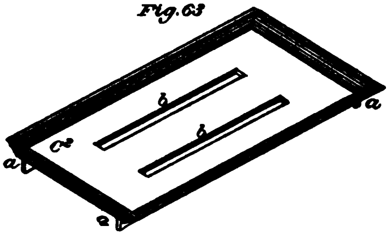


Fig. 62 is a cross-section of a boiler, showing Fisk's improvement applied thereto. Fig. 63 is a perspective view of the upper removable pan, which is placed in the boiler.

A represents a boiler, which is shown in cross section, and B B represents the ordinary flue pipes.

C C′ C² represent a series of very shallow pans, made preferably of sheet metal—such as galvanized iron or tin—with flaring sides. The lower pan rests on legs *a* on top of the boiler flues. The other pans also have short legs *a a,* which stand loosely in the pans below, and they are thus removable separately, being inserted and taken out through the manhole of the boiler. The upper and lower pans are of large size, and the middle one of small size, comparatively, and the upper one has two longitudinal slots *b b* opening through it, while the two lower ones are imperforated, as shown.

D is the ordinary feed-water pipe, which passes through the top of the boiler and rests over the central portion of the upper pan, between the two slots. If desired, more than three of the pans may be employed, the same general arrangement being followed—*i. e.*, the upper pan being slotted, and every intermediate pan being of smaller diameter than the alternate ones.

The operation is as follows: The feed water dropping from the pipe is spread over the bottom of the upper pan, but without filling it, as the water passes at once through the slots to the second pan. The thin sheet of water in this first pan allows the great mass of scale contained in the water to be deposited on this pan alone, which gathers more particularly in the center between the slots and in the edges of the slots, and is therefore more readily removed than where it spreads evenly over a very large surface. The water then fills the second pan, and from this it runs over the edges and falls into the third pan and fills it, and finally escapes into the boiler. In passing the several pans the water also runs over the bottoms in a thin sheet, and more or less of the scale is deposited over the whole surface of the pans. From the peculiar construction of the upper pan, however, as before described, whereby the water simply runs in a thin sheet over the whole surface and does not gather in a body, the great deposit of the scale is on the upper pan, where it may be readily removed by removing the pan, without disturbing the other pans; or all may be removed at the same time where there is sufficient deposit.

Many forms of apparatus for the deposit of scale are well known, and Mr. Fisk makes no claim to advantages other than that of removable pans resting one above another, and the use of an upper pan having a slotted bottom, by which the water is spread in a thin sheet and discharged centrally.

Ashcroft's Electrical Alarm and Steam-Boiler Cleaner.

The object of Ashcroft's invention, shown in Figs. 64 and 65, is to remove the scum and earthy matter floating on the surface of the water, and to prevent the formation of scale and incrustation on the boiler plates and tubes of the boiler. It relates, also, to means whereby notice may be had when the cleaner is not in operation.

To this end Ashcroft's invention consists in locating in a boiler a series of receiving cups, or a trough mounted upon a pipe preferably suspended horizontally lengthwise of the boiler its entire length, the pipe being provided with a chamber of any approved shape or size and a float within the chamber, the float having a stem provided with a metallic point of good conductivity, this float, with its pointed stem or rod, being so arranged that when the water in the boiler rises to a certain level the metal point is brought into contact with electric conductors, whereby an electric circuit is completed and the alarm is sounded at any place desired.

The chief features of this device consist, in the first place, in removing the gross earthy matter or scum contained in or settling in the water.

It consists, secondly, in devices for automatically announcing or reporting the active operation of the device by causing the alarm to be sounded while the water in the boiler is at or above a certain

Fig. 64.

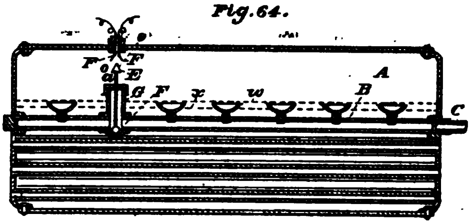
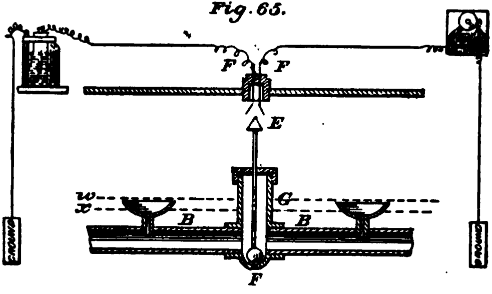


Fig. 65.



height, at which the impurities or scum are being ejected through the cleaning or blow-off pipe.

To insure frequent and regular operation in blowing off the scum and to detect the non-use of the cleaner is the principal object of Ashcroft's invention.

Fig. 64 shows a longitudinal section of a boiler with Ashcroft's invention attached. Fig. 65 shows an enlarged detail of the apparatus.

A represents the boiler; B, the blow-off pipe, made in two sections, one end of each section entering the boiler head, and the other end of each section entering a chamber, G, somewhat the contour of the body of a globe valve. The chamber G extends above the water line of the boiler and below the bottom of the pipe B. In chamber G the inventor places a float, F, to which are attached a stem, *a*, and point E. The top wall of the chamber is provided with an aperture, through which the stem *a* projects, the stem being made to easily fit the aperture, which also serves as a guide to the stem. Through the shell of the boiler the inventor makes an opening in a line over the float chamber, into which is secured, steam tight, a hollow plug or cap provided with electrical springs, insulated, which connect with electrical wires, also insulated. The wires of course connect with an electric battery. The electrical springs extend from the cap down into the boiler a sufficient length to allow the metal point to come in contact with them when the float rises, and thus an electrical circuit is formed which by certain means sounds an alarm, giving notice that the blow-off should be put in operation.

The operation is as follows: The working water level of the boiler is indicated in dotted lines *x* in the drawings, and the line of water level *w*, at which the scum should be discharged through the cleaning apparatus, is also shown in the drawings by dotted lines. At certain hours of the day—say at 10 o'clock a. m.—the engineer is directed to use the blow-off valve connected with the apparatus, and previous to the time named, at which time the cleaner is to be operated daily, the line of water level in the boiler is to be raised in the usual way from the working level to the line of blow-off. When the water is raised to the line of blow-off above the cleaning cups the float chamber fills and the float rises, bringing the metal point in contact with the electrical springs, through which the electric current is formed with the battery and the alarm is sounded. The blow-off should then commence and continue until the line of water in the boiler is reduced below the cups, when the float will fall to its seat in the chamber and the electric current will be broken, causing the alarm to cease sounding. Thus, if the alarm is not operated, either through neglect of the engineer or through the derangement of the apparatus in some of its parts, notice of non-operation will be made known where the alarm is located.

LIST OF ALL PATENTS

FOR

COMPOSITIONS FOR PREVENTING AND LOOSENING THE INCRUSTATIONS OF STEAM BOILERS AND FOR PURIFYING WATER, ISSUED BY THE GOVERNMENT OF THE UNITED STATES OF AMERICA FROM 1790[1] TO JULY 1, 1884, INCLUSIVE.

No.	Date.	Inventor.	Residence.
....	Oct. 4, 1836	M. Park	Madison, Ind.
4189	Sept. 11, 1845	L. A. Ritterbrandt	London, Eng.
4903	Dec. 22, 1846	S. D. Anthony and D. Barnham.	New York, N. Y.
17046	April 14, 1857	R. McCafferty	Lancaster, Pa.
26683	Jan. 3, 1860	H. F. Knoderer and L. F. Knoderer	Chillicothe, Ohio.
34188	Jan. 21, 1862	L. Baird	Cambridge, Mass.
44001	Aug. 30, 1864	F. Lanbrun	New Orleans, La.
45303	Nov. 29, 1864	A. Temple	Bridgeport, Conn.
45914	Jan. 17. 1865	D. Embree	Dayton, Ohio.
47188	April 11, 1865	J. Buzby	Philadelphia, Pa.
47794	May 23, 1865		
47914	May 30, 1865	A. B. Auer	Babcock's Grove, Ill.
49569	Aug. 22, 1865	A. Temple	Bridgeport, Conn
49931	Sept. 12, 1865	G. R. Spannagel	St. Louis, Mo.
50237	Oct. 3, 1865	J. R. Gansz and J. J. Lavo	St. Louis, Mo.
51775	Dec. 26, 1865	W Brown	Morrison, Ill.
57219	Aug. 14, 1865	N. S. Thomas.	Painted Post, N. Y.
58660	Oct 9 1866	C. McKee	San Francisco, Cal.
58961	Oct. 16, 1866	S. Delong	Paris, France.
63453	April 2, 1867	J. J. Allen	Philadelphia, Pa.
65092	May 28, 1867	H. F Knoderer and L. F. Knoderer.	Columbus, Ohio.
65657	June 11, 1867	C J. Eames	New York. N. Y.
67973	Aug. 20, 1867	M. A Glynn	Havana, Cuba.
80544	Aug. 4, 1868	W. Hewitt	Pimlico Eng.
84489	Dec. 1, 1868	G. Hawxhurst	Sonersville, Cal.
89112	April 20, 1869	S Brock	New Orleans, La.
93182	Aug. 3, 1869	R. D'Heureuse	New York, N. Y.

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[1] By act of April 10, 1790, the first American patent system was founded. It is a source of regret that no well-preserved history of any class of American inventions dating from this time is in existence, and that no classified list of models which were in the Patent Office at the time of the fire of 1836 can be obtained. The earliest date that can be reached is January 21, 1823, and that is only partially complete.

List of Patents—*Continued.*

No.	Date.	Inventor.	Residence.
98173	Dec. 21, 1869	G. W. Lord	Philadelphia, Pa.
100358	Mar. 1, 1870	C. Burks	Marine, Ill.
103661 103662	May 31, 1870	J. Rogers	Madison, Ind.
103974	June 7, 1870	W. H. Burridge	Cleveland, Ohio.
110463	Dec. 27, 1870	J. A. Hewett	Nora Springs. Iowa.
111198	Jan. 24, 1871	W. T. Grant	Neelyville, Ill.
112226	Feb. 28, 1871	R. D'Heureuse	New York, N. Y.
114776	May 16, 1871	G. C. T. Degenhardt	Williamsburgh, N. Y.
117462	July 25, 1871	W. T. Rickard	New Monitor, Cal.
119426	Sept. 26. 1881	C. A. Sweet	Ripon, Wis.
119830	Oct. 3, 1871	C. G. Dodge	Marshall Mich.
132369	Oct. 22, 1872	W. Pearson	Chicago. Ill.
132489	Oct. 22, 1872	J. Chandler	Pioneer, Pa.
132820	Nov. 5, 1872	R. J. Ellis and J. Dobson	Liverpool, Eng.
137935	April 15, 1873	J. J. Lavo	Wyandotte, Kan.
140263	June 24, 1873	R. A. Fisher	San Francisco, Cal.
140589	July 8, 1873	T. E. Petersen	Copenhagen, Denmark.
143240	Sept. 30, 1873	R. Hatfull	Deptford, Eng.
143676	Oct. 14, 1873	J. Demailly	Brussels, Belgium.
144254	Nov 4, 1873	C. Burfitt	New Wimbledon, Eng.
149097	Mar. 31, 1874	H. Burgess	Royer's Ford, Pa.
153036	July 14, 1874	J. Bernhard	Paris, France.
156103	Oct. 20, 1874	T. Routledge and W. H. Richardson	Ford, Eng.
157285	Dec. 1. 1874	L. E. Hurd	Indianapolis, Ind.
157917	Dec. 22, 1874	J. J. Lavo	Kansas City, Mo.
160030	Feb. 23, 1875	J. H. Pitts	Oakland, Cal.
162491	April 27, 1875	G. A. Moore and W. McCloud.	Columbus, Ohio.
168222	Sept. 28, 1875	H. Burgess	Roger's Ford, Pa
169219	Oct. 26, 1875	J. M. Wishart	Boone, Iowa.
170137	Nov. 16, 1875	E. Weiss	Basle, Switzerland.
171297	Dec. 21, 1875	L. N. Lye	Allen County, Ohio
171599	Dec. 28, 1875	A. Chavasse	Montreal, Canada.
172390	Jan. 18, 1875	J. Clegg	Baltimore, Md.
177513	May 6, 1875	O Holden	Chicago, Ill.
181373	Aug. 22, 1875	R. R. Taylor	Reading, Pa.
182774	Oct. 3, 1875	J. Riley	Chicago, Ill.
190436	May 8, 1877	L. E. Hurd	Cincinnati, Ohio.
190770	May 15, 1877	H. H. Kreamer	Reading, Pa.
199309	Jan. 15, 1878	J. North	Keokuk, Iowa.
206161	July 23, 1878	E. Bohling	Eisenach, Germany.
209186	Oct. 22, 1878	F. J. Obert	Reading, Pa.
209574	Nov. 5. 1878	F. M. Maybury	Milwaukee, Wis.
219742	Sept. 16, 1879	F. Leporin	New York, N. Y.
230903	Aug. 10, 1880	J. B. Sawash and G. V. Wright.	Patterson, Iowa.
231909	Sept. 7, 1880	F. Henderson	Toledo Ohio.
235633	Dec. 21, 1880	H. Heiman	Cologne, Germany.
239242	Mar. 22, 1881	W. J. Gillespie	Indianapolis, Ind.
239417	Mar. 29, 1881	P. Alfierie	Naples, Italy.
258235	May 23, 1882	H. Kolker	Breslau, Germany.
259355	June 13, 1882	C. B. Boyce	Chicago, Ill.

List of Patents—*Continued.*

No.	Date.	Inventor.	Residence.
260003	June 27, 1882	F. M. Collett	Dubuque, Iowa.
261180	July 18, 1882	A. Temple	Bridgeport. Conn.
264182	Sept. 12, 1882	I. L. Merrell	San Francisco, Cal.
267743	Nov. 21, 1882	C. B. Dudley	Altoona, Pa.
268461	Dec. 5, 1882	C. Cryer and G. H. Norris	San Francisco, Cal.
269616	Dec. 26, 1882	C. R. Bacon and F. Queen	St. James, Minn.
274666	Mar. 27, 1888	T. Shuhan	Dunkirk, N. Y.
275277	April 3, 1883	G. Seiler	Spring Forge, Pa.
277112	May 8, 1883	G. Dowine	Salinas, Cal.
283472	Aug. 21, 1883	C. B. Dudley	Altoona, Pa.
291167 291168	Jan. 1, 1884	C. B. Dudley	Altoona, Pa.
293740 to 293749 Inclusive.	Feb. 19, 1884	I. S. Hyatt	Morristown, N. J.
295309	Mar. 18, 1884	F. Troxel	Danville, Ill.
295890	Mar. 25, 1884	W. Tweeddale	Topeka, Kan.

LIST OF ALL PATENTS

FOR

MECHANICAL APPLIANCES FOR PREVENTING AND REMOVING THE INCRUSTATIONS OF STEAM BOILERS AND FOR PURIFYING WATER,[1] ISSUED BY THE GOVERNMENT OF THE UNITED STATES OF AMERICA FROM 1790 TO JULY 1, 1884, INCLUSIVE.

No.	Date.	Inventor.	Residence.
10964	May 23, 1854	J. McMullen	Baltimore, Md.
12261	Jan. 16, 1855	G. Weissenborn	New York, N. Y.
12654	April 3, 1855	H. Strait	Covington, Ky.
13488	Aug. 28, 1855	F. P. Dimpfel	Philadelphia, Pa.
14230	Feb. 12, 1856	W. E. Evett and M. Minthorne.	New York, N. Y.
22178	Nov. 30, 1858	H. H. Havens	New York, N. Y.
22249	Dec. 7, 1858	J. W. Hartnett	Cincinnati. Ohio.
23320	Mar. 22, 1859	A. M. Sprague	Mobile, Ala.
28303	May 15, 1860	J. T. Price	Rockville, Ind.
30511	Oct. 23, 1860	N. B. Webster and R. W. Young.	Portsmouth, Va.
33828	Dec. 3, 1861	G. C. L. Dagenhardt	Tresckow, Pa.
34455	Feb. 18, 1862	S. A. Wilcox	West Roxbury, Mass.
35678	June 24, 1862	W. Harrison, Jr.	Philadelphia, Pa.
45914	Jan. 17, 1865	D. Embree	Dayton, Ohio.
46439	Feb. 14, 1865	J. Daley and J. H. Marville.	Philadelphia, Pa.
47232	April 11, 1865	E. Thayer	Worcester, Mass.
49255	Aug. 8, 1865	P. E. Garvin	Philadelphia, Pa.
49327	Aug. 8, 1865	J. Werner, Jr	Prairie du Lac, Wis.
50773	Oct. 31, 1865	G. T. Parry	Philadelphia, Pa.
50774	Oct. 31, 1865	A. T. Porter	Philadelphia, Pa.
51775	Dec. 26, 1865	W. Brown	Morrison, Ill.
54962	May 22, 1866	P. C. Row	Boston, Mass.
59768	Nov. 20, 1866	A. T. Hay	Burlington, Iowa.
62093	Feb. 12, 1867	P. H. Vander Weyde	Philadelphia, Pa.
62878	Mar. 12, 1867	G. T. Parry	Philadelphia, Pa.
63869	April 16, 1867	C. J. Dumèry	Paris, France
64992	May 21, 1867	D. Matthew	Prairie du Chien, Wis.
68041	Aug. 27, 1867	S. G. Cabell	Quincy, Ill.
69096	Sept. 24, 1867	J. L. Husband	Philadelphia, Pa.
71451	Nov. 26, 1867	S. G. Cabell	Quincy, Ill.
72309	Dec. 17, 1867	D. Matthew	Prairie du Chien, Wis.

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[1] This list includes all American patents for feed-water heaters that filter or otherwise purify the water; but patents for feed-water heaters which simply heat the water without purifying it are not included.

List of Patents—*Continued*.

No.	Date.	Inventor.	Residence.
72794	Dec. 31, 1867	S. G. Cabell	Quincy, Ill.
73872	Jan. 28, 1868		
82859	Oct. —, 1868	H. McQuaid	Canyon City, Ore.
84671	Dec. 6, 1868	R. B. Baker and C. J. A. Dick.	Pittsburgh, Pa.
89725	May 4, 1869	T. Barfield	Athens, N. Y.
91801	June 22, 1869	J. Webster	Chelsea, Eng.
93852	Aug. 17, 1869	G. W. Baird	U. S. Navy.
97657	Dec. 7, 1869	R. Lightall	Brooklyn, N. Y.
101248	Mar. 29, 1870	J. T. Fisher	Pittsburgh, Pa.
109453	Nov. 22, 1870	B. W. Reynolds	Evansville, Ind.
110553	Dec. 27, 1870	C. J. A. Dick	Paris, France.
113405	April 14, 1871	C. W. Deane	Philadelphia, Pa.
116792	July 15, 1871	J. Argall	Mineral Point, Wis.
119185	Sept. 19, 1871	W. C. Selden	Brooklyn, N. Y.
119597	Oct. 3, 1871	J. Gates	Portland, Ore.
121445	Nov. 28, 1871	A. Zipser	Biola, Austria.
123310	Jan. 30, 1872	P. V. Vigier	Paris, France.
132439	Oct. 22, 1872	J. Chandler	Pioneer, Pa.
134811	Jan. 14, 1873	J. Leonard and S. Hancock.	Oroville, Cal.
137878	April 15, 1873	W. T. Bate	Norristown, Pa.
139634	June 3, 1873	C. N. Tyler	Buffalo, N.Y.
140196	June 21, 1873	A. T. Hay	Burlington, Iowa.
143676	Oct. 14, 1873	J. Demailly	Brussels, Belgium.
150038	April 21, 1874	G. Hicks	Cincinnati, Ohio.
153012	July 14, 1874	W. O'Brien	Mattoon, Ill.
154921	Sept. 8, 1874	F. Sourmer	Berlin, Germany.
155620	Oct. 6, 1874	N. R. Nixon	Richmond, Ind.
157334	Dec, 1, 1874	G. F. Jasper	Freeburg, Ill.
157361	Dec. 1, 1874	G. R. Zscheck	Indianapolis, Ind.
159142	Jan. 26, 1875	G. W. Baird	U. S. Navy.
160009	Feb. 23, 1875	J. F. Donoghue	Springfield, Mass.
166782[1]	Aug. 17, 1875	T. O. Kemp	Beamsville, Canada.
168779	Oct. 11, 1875	J. Popper	Vienna, Austria.
169074	Oct. 26, 1875	W. Andrews and J. Wallace.	Keokuk, Iowa.
175402	Mar. 28, 1876	J. L. Winston	Newport, Ky.
176018	April 11, 1876	J. L. Lloyd	Williamston, Mich.
184346	Nov. 14, 1876	C. J. Cronin	Barnhart's Mills, Pa.
184948	Dec. 5, 1876	J. J. Adgate F. Hickman	New York, N. Y. Reading, Pa.
190603	May 8, 1877	W. Major	Copenhagen, Denmark.
191939	June 12, 1877	T. Craney	Bay City, Mich.
192741	July 3, 1877		
194036	Aug. 14, 1877	J. A. Fardan J. E. Thomas	Bay City, Mich. Wenona, Mich.
194084	Aug. 14, 1877	S. D. Gilson	Syracuse, N. Y.
194723	Aug. 28, 1877	E. Ransom	Flint, Mich.

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[1] Patent No. 166782 has been assigned to James F. Hotchkiss, and it is the foundation patent in America for apparatus for cleaning boilers by collecting the impurities of the water as they rise to the surface in the boiler, and then conveying it into a reservoir from whence the pure water flows back into the boiler through a return pipe and the sediment is discharged through a blow-off pipe.

List of Patents—*Continued.*

No.	Date.	Inventor.	Residence.
196013	Oct. 9, 1877	E. H. Hermans W. D. Smith	Reed's Landing, Minn. Keithsburg, Texas.
196642	Oct. 30, 1877	W. Dunn	Philadelphia, Pa.
196808	Nov. 6, 1877	N. A. T. Jones	Plymouth, Mass.
196988	Nov. 13, 1877	J. F. Morse	Oshkosh, Wis.
201181	Mar. 2, 1878	S. Huges	Charleston, S. C.
201446	Mar. 19, 1878	T. C. Purves	Chicago, Ill.
203646	May 14, 1878	J. J. Ralya	Cleveland, Ohio.
204250	May 28, 1878	T. C. Purves	Chicago, Ill.
208794	Oct. 8, 1878	A. Collins	New Vienna, Ohio.
213498	Mar. 29, 1879	A. P. Doen and J. C. C. Miller.	Evansville, Ind.
213582	Mar. 29, 1879	T. McAlvin and M. Spiegel.	Cincinnati, Ohio.
215161	May 6, 1879	L. Reinhardt	Havana, Cuba.
218446	Aug. 12, 1879	R. Llewellyn	San Francisco, Cal.
219840	Aug. 16, 1879		
220445	Oct. 7, 1879	J. L. Thompson	Allegheny, Pa.
225622	Mar. 16, 1880	W. Linehan	Chicago, Ill.
226068	Mar. 30, 1880	S. J. Hayes, E. T. Jeffery, and H. Schlacks.	Chicago, Ill.
226939 227072	April 27, 1880	G. S. Strong	Philadelphia, Pa.
227605	May 11, 1880	W. Youngblood and T. C. Holmes.	New Orleans, La.
229051	June 22, 1880	W. Morehouse	Buffalo, N. Y.
230248	July 20, 1880	A. Dervaux	Brussels, Belgium.
239101	Mar. 22, 1881	B. Kane	Cincinnati, Ohio.
240813	May 3, 1881	S. E. Collins	Marion, S. C.
241360	May 10, 1881	S. J. Hayes, E. T. Jeffery, and H. Schlacks.	Chicago, Ill.
243912	July 5, 1881	A. Johnson	Young America, Ind.
244249	July 12, 1881	T. J. Jones	Sharon, Pa.
244668	July 19, 1881	C. Reiser	Prairie du Chien, Wis.
246910	Sept. 13, 1881	E. Root	Buffalo, N. Y.
247736	Oct. 4, 1881	E. A. Ashcroft	Lynn, Mass.
247948	Oct. 4, 1881	C. Reiser	Prairie du Chien, Wis.
248008	Oct. 11, 1881	A. Berney	Boston, Mass.
250519 250520	Dec. 6, 1881	C. A. French	Davenport, Iowa.
250599	Dec. 6, 1881	G S. Strong	Philadelphia, Pa.
252243	Dec. 20, 1881	D. Kelly W. H. Hoffman	Philadelphia, Pa. Passaic, N. J.
252974	Jan. 31, 1882	T. Shaw	Philadelphia, Pa.
254118	Feb. 28, 1882	T. Craney	Bay City, Mich.
254307	Feb. 28, 1882	D. Hanna	Ogdensburgh, N. Y.
254446	Mar. 7, 1882	E. H. Ashcroft	Lynn, Mass.
254698	Mar. 7, 1882	A. Rogers	Barnesville, Ohio.
255532	Mar. 28, 1882	H. Pinder and G. W. Clark	New York, N. Y.
259693	June 20, 1882	T. J. Jones	Sharon, Pa.
260676	July 4, 1882	D. Hanna	Ogdensburgh, N. Y.
261468	July 18, 1882	J. E. Mendenhall	Springfield, Ohio.
261612 261613	July 25, 1882	N. A. T. Jones	Plymouth, Mass.

List of Patents—*Continued.*

No.	Date.	Inventor.	Residence.
262147	Aug. 1, 1882	G. S. Strong	Philadelphia. Pa.
262823	Aug. 15, 1882	W. Ord	Brooklyn, Ohio
264468	Sept. 19, 1882	H. Stranton	Flushing, Ohio.
265365	Oct. 3, 1882	E. H. Ashcroft	Lynn, Mass.
266686	Oct. 31, 1882	E. Fox	Brooklyn, N. Y.
268672	Dec. 5, 1882	H. Hill	Joliet, Ill.
270569	Jan. 9, 1883	E J. Hoffman	Sioux City, Iowa.
271821	Feb. 6, 1883	C. Elliot	San Francisco, Cal.
272770	Feb. 20, 1883	C. Reiser	Prairie du Chien, Wis.
273026	Feb. 27, 1883	G. A. Chapman	Strawberry Point, Iowa.
273777 273778	Mar. 13, 1883	G. S. Strong	Philadelphia, Pa.
276189	April 24, 1883	J. T. Mead	Cleveland, Ohio.
276410 276411	April 24, 1883	J. F. Hotchkiss	Plainfield, N. J.
276493	April 24, 1883	J. Spaulding	San Francisco, Cal.
276627	May 1, 1883	T. C. Purves	Chicago, Ill.
277285	May 8, 1883	J. W. Hubber	San Francisco, Cal.
278196	May 23, 1883	E. R. Stilwell	Dayton, Ohio.
281013	July 10, 1883	T. R. Butman	Cleveland, Ohio.
281775	July 24, 1883	W. S. McKinney	Binghamton, N. Y.
282804	Aug. 7, 1883	W. P. Thompson.	Philadelphia, Pa.
285248	Sept. 18, 1883	G. C. Fisk	Dansville, N. Y.
285591	Sept. 25, 1883	C. B. Dudley	Altoona, Pa.
285615	Sept. 25, 1883	J B. Hannay	Glasgow, Scotland.
285825	Sept. 25, 1883	D. McCurdy	Ottawa, Can.
286705	Oct. 16, 1883	N A. T. Jones	Plymouth, Mass.
286724	Oct. 16, 1883	J. McGinley	Chicago, Ill.
292076	Jan. 15. 1884	E. W. Vanduzen	Newport, Ky.
293172	Feb. 5, 1884	E. J. Hoffman	Sioux City, Iowa.
293740 to 293749 inclusive.	Feb. 19, 1884	I. S. Hyatt	Morristown, N. J.
295890	Mar. 25, 1884	W. Tweeddale	Topeka, Kan.
296337 298101	May 6, 1884	A R. Leeds	Hoboken, N. Y.

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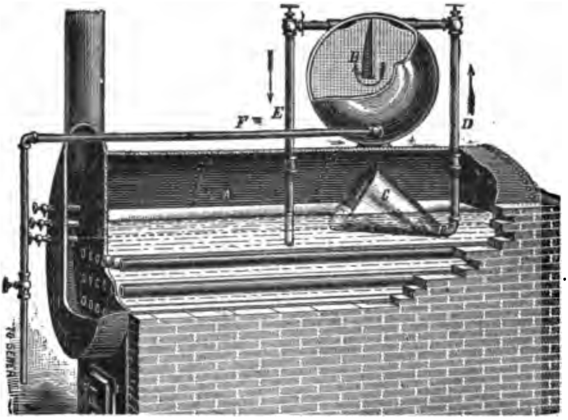

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JAS. F. HOTCHKISS:

We authorize you to say that the Cleaner is entirely satisfactory, and we believe does what you claim for it. Yours, respectfully, ALLISON & ADDISON.

RICHMOND, June 28, 1884.

Please send as quickly as you can two (2) more Boiler Cleaners. This order shows what we think of the one we have had in use for some months better than anything we could say.

Respectfully, ALLISON & ADDISON.

SUGAR REFINERY, GIRARD CORNER COMMERCE,
WM. HENDERSON, DEALER IN SUGAR AND MOLASSES,
NEW ORLEANS, March 26, 1884.

JAS. F. HOTCHKISS,

SIR: I enclose my check on your city for amount of bill for three (3) Cleaners shipped me. The report I have of the working of the Cleaners is quite favorable. The boilers are much cleaner than usual, much of the surface being entirely clean, and the old scale is detached a great deal, and promises to drop off entirely. The boilers are not quite clean and free from scale, but I am confident they soon will be. Yours, truly, WM. HENDERSON.

OFFICE OF SILVER GLANCE MINING COMPANY,
IDAHO SPRINGS, COLO., January 15, 1884.

JAS. F. HOTCHKISS,

SIR: Received the Boiler Cleaner you sent us, and put it on the 20th. Am perfectly satisfied with its work. The water we use is from the *mine*, and, as we are sinking the shaft, the water is very dirty, but after two weeks' use with the Cleaner attached we opened the boiler and not a particle of dirt or grit was to be found.

Yours, etc., L. H. TOURTELLOTTE, *Supt.*

BUCKEYE MILL CO., MARYSVILLE, CAL., May 4th, 1884.

SIR: The Hotchkiss Cleaners are doing splendid work on our two boilers and are doing all that is claimed for them. Our president is now in the east and on his return will doubtless have them put on the other boilers. Yours, truly, BUCKEYE MILL CO.,
Per F. H. GREELY, Acting Pres.

E. S. WARD & CO., MANUFACTURERS OF PATENT AND ENAMELED LEATHER,
NORFOLK AND RICHMOND STREETS, NEWARK, N. J., January 4, 1884.

JAS. F. HOTCHKISS,

DEAR SIR: The Hotchkiss Boiler Cleaner you put on our boiler October 8th last does its work in a satisfactory manner, as far as we can judge. It has taken out a considerable quantity of mud, and when we examined the boiler about six weeks after the Cleaner was attached, we found the condition to be the same as you represented it would be. In short, we believe that the Cleaner will do all that you claim for it. Yours, truly, E. S. WARD & CO.

NEWARK, January 4th, 1884.

I have been at E. S. Ward & Co.'s factory a number of times when the blow-off from the Cleaner has been opened, and saw large quantities of mud blown out, showing that the machine does its work. OSCEOLA CURRIER, *Machinist.*

J. S. ELLIFRITZ & CO., HILLSBORO' WOOLEN MILLS,
HILLSBORO', OHIO, November 21, 1883.

JAS. F. HOTCHKISS, 86 John St., New York,

SIR: Enclosed find draft on New York for Boiler Cleaner purchased of you some time ago. Would have remitted ere this, but our cleaner did not work (until lately) to our satisfaction, and all on our own account, from not having it set all right; did not get the funnel low enough; but since we have got it right it works like a charm, and are better pleased with it every day we use it. Run the last four weeks since opened, and only found one quarter pint of sediment in the boiler. You will please ship one to our neighbors, Messrs. Heistand & Cowman, of this place. Yours, respectfully, J. S. ELLIFRITZ & CO.

HOOSAC MINING AND MILLING CO., IDAHO SPRINGS, COLO., December 28, 1883.

JAS. F. HOTCHKISS, 86 John St., New York,

DEAR SIR: I am waiting to test your Cleaners in water from our shaft while sinking, as our water for boilers all comes from under ground. As soon as this test is made of them I will forward you certificate and check for the amount. *So far as tested they are superb.*

Yours, respectfully, J. V. W. VANDENBURG, *Manager.*

LAFLIN AND RAND POWDER CO., 29 MURRAY ST., NEW YORK, February 8th, 1883.

JAS. F. HOTCHKISS, ESQ.,

DEAR SIR: On learning that our Powder Works at Platteville, Wis., were using a so-called "Purvis Boiler Cleaner," we instructed our manager there to notify Messrs. Purvis & Reynolds, of Chicago, to remove the same and refund our money paid in error. We instructed Mr. Collier, manager, to advise Messrs. Purvis & Reynolds to desist from the use of our name in any manner. We learn at this date that Messrs. Purvis & Reynolds not only continue to use our name, but have changed the *language* and *date* of a testimonial, given after about two months' trial of their "cleaner," which is without our consent and apparently attempting to deceive the public. You have permission to publish this if desirable, together with the statement that having the "Hotchkiss Cleaner" at our different mills, we consider it the original, the best, and the cheapest, and we do not endorse any imitation knowingly. You may send one of your "Cleaners" to our mills at Platteville, Wis., to take the place of the "Purvis" removed. Yours, truly, SOL. TURCK, *Pres.*

CARRIAGE, FIRE AND STOVE BOLTS, CLEVELAND, OHIO, October 28th, 1882.

JAS. F. HOTCHKISS:

We enclose herewith draft for settlement of your invoice for three Boiler Cleaners. We are pleased to say that they work very satisfactorily. LAMSON, SESSIONS & CO.

UNION ROLLING MILL CO., NEWBURGH, OHIO, April 24, 1882.

JAS. F. HOTCHKISS, ESQ., New York,

DEAR SIR: Your favor of 22d inst. received, covering invoice of three Cleaners. Enclosed we remit you for same. We are much pleased with the Cleaners, and think without them would soon have tubes thoroughly covered. You can refer to me if desired.

Yours, truly, J. MORGAN COLEMAN, *Supt.*

THE EMPIRE GRAIN DRILL AND EXCELSIOR HORSE YOKE,
SHORTSVILLE, ONTARIO CO., N. Y., May 10, 1882.

JAS. F. HOTCHKISS, New York,

DEAR SIR: For the past five months we have been using one of your mechanical Boiler Cleaners upon our 50 H. P. boiler. During that time the boiler has been in use night and day, and has never been blown off for examination.

Last Friday, May 5, we had the boiler blown off, and the water that came from it, to the last drop, was as clear as spring water and the sediment or scale remaining in the boiler could be held in one hand. You are at liberty to use our name as a reference as to the value of your device to boiler users, and we will cheerfully answer any inquiries you may refer to us. We are highly gratified with its operation, and lack of words only limits our expressions of admiration.

We have given away our circular; wish you would send us two or three more. The Star Paper Company, of this place, are rebuilding their mill, and are putting in three new 6c H. P. boilers. The Supt. was just in and wished a circular, and we told him we would get one for him. He has always been very skeptical as to its value and capacity to do the work for which it was recommended. He examined our boiler and pronounced it in finer shape than he ever saw one after so long usage. He told us that he would have one on each of his boilers. Trusting that you may secure their orders, we remain,

Yours, etc., EMPIRE DRILL CO.

H. B. BIGELOW & CO., ENGINE AND BOILER MAKERS,
NEW HAVEN, CONN., Aug. 9th, 1881.

Mr. JAS. F. HOTCHKISS, 86 John St., N. Y.,

DEAR SIR: Replying to yours of the 8th inst., would say that we have used your Boiler Cleaner for the past five years, having had it in constant use, and we consider it the most reasonable and satisfactory Cleaner that we have ever heard of. We cheerfully recommend it to any one that is using a boiler, as it will certainly keep the boiler remarkably clean.

Yours, truly, H. B. BIGELOW & CO.

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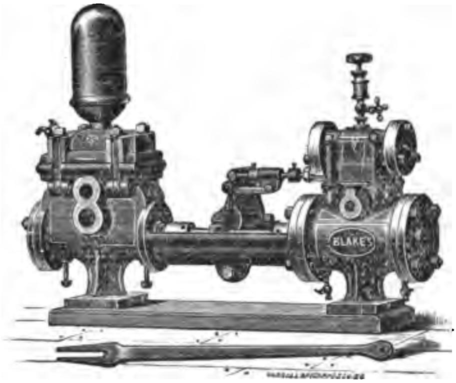

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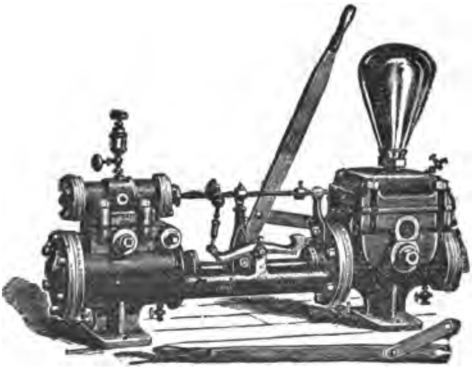

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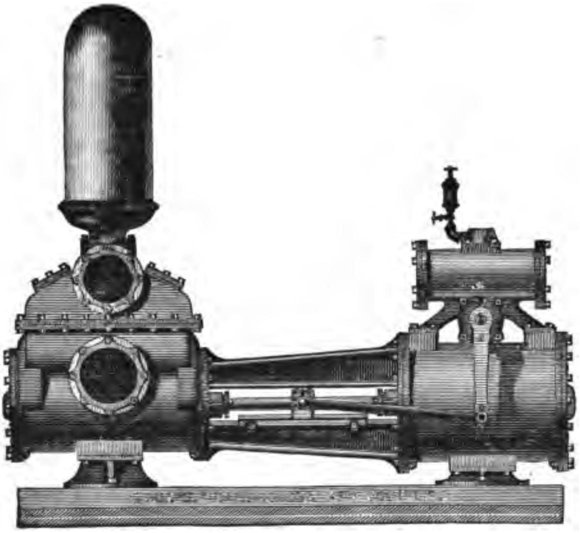

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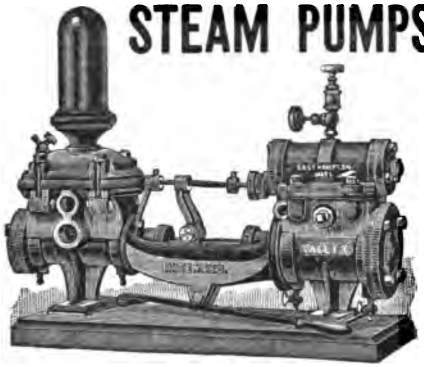

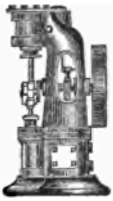

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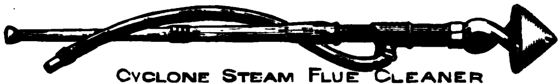

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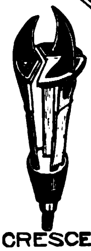

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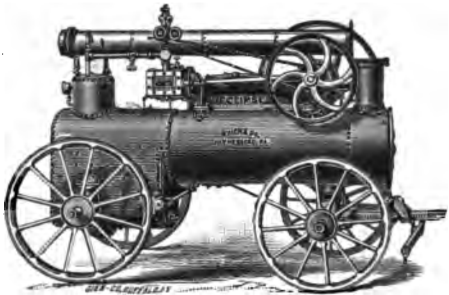

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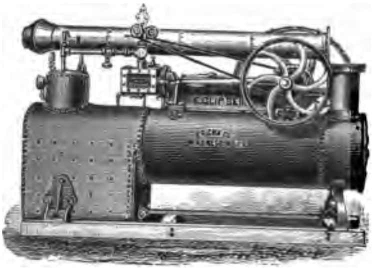

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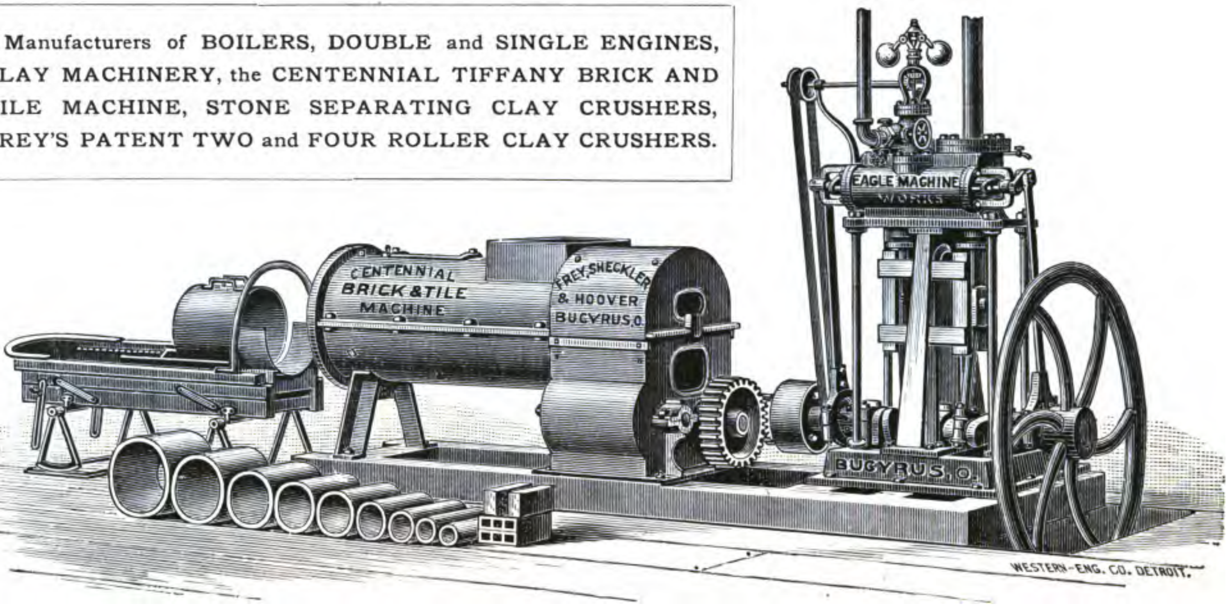

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